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CORRECTION

MONTHLY WEATHER REVIEW, April, 1927, page 184:

In the second column the paragraph beginning "Freak conditions, often reported, etc.", belongs at the end of the article on page 183, following the paragraph ending " * * * although still standing."

MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

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MAY, 1927

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THE NORTHEAST TRADE WINDS OF THE NORTH PACIFIC

By E. A. BEALS

CHAPTER I

GENERAL RELATIONS OF THE TRADE WINDS TO PRESSURE DISTRIBUTION

Since the relative pressure of the atmosphere determines the force and direction of the prevailing winds, it is obvious that the first step toward a proper understanding of the wind systems of the globe is an examination of the general pressure distribution.

Broadly speaking, the chief features of world-pressure distribution are: (1) An equatorial belt or zone of diminished pressure, (2) a belt or zone of high pressure around the world about 30° both north and south of the Equator, and (3) a second belt of low pressure about north latitude 60° and a similar belt in the Southern Hemisphere in approximately the same latitude.

The belts of high pressure about 30° from the Equator are not continuous around the world but form a series of the well-known semipermanent anticyclones, each with its appropriate wind circulation. Similarly the belts of low pressure about 60° from the Equator are not continuous but rather a disconnected series of cyclonic wind systems which reach their greatest development in winter and over the oceans rather than the continents. The best known of these are found in the Northern Hemisphere along the Aleutian Islands in the Northeast Pacific and in the vicinity of Iceland in the Northeastern Atlantic. These two well-known semipermanent cyclcones are known as the Aleutian cyclone or LOW and the Iceland cyclone or LOW, respectively.

The most prominent semipermanent anticyclones in the Northern Hemisphere are the great Siberian anticyclone of winter, and winter only, and the two oceanic anticyclones, the Azores in the Atlantic and the North Pacific in the ocean of that name. The oceanic anticyclones are best developed in summer.

The wind circulation in these anticyclones is spirally outward from the center in a clockwise direction; that of the cyclone is exactly the opposite.

Both the cyclones and anticyclones above mentioned must not be confused with the traveling cyclones and anticyclones of the daily weather map. The latter preserve their form and travel in a definite direction over the earth's surface for a time. The former, on the other hand, must not be thought of as having a distinct entity which is continually preserved. Rather they should be thought of as representing the average monthly pressure distribution in their respective areas, and this monthly average is the result of many diverse pressure distributions. It is important that this truth be brought home to writers on pressure distribution and its influence upon the weather.

Figures 1 and 2 have been prepared to show the average pressure distribution and the prevailing winds in the Northern Hemisphere for January, a winter month, and July, a summer month. The data are taken from the United States Hydrographic Office Pilot Charts.

The pressure distribution in the Southern Hemisphere is similar to that shown in Figures 1 and 2 except that the large oceanic anticyclones are not disposed symmetrically with those of the Northern Hemisphere; thus, for example, the anticyclone in the South Pacific is situated much nearer to the Continent of South America than the corresponding North Pacific anticyclone is to the Continent of North America.

Recalling the statement previously made as to the existence of a zone of low pressure in the equatorial regions that is bounded on both sides by belts of higher pressure, it will be readily understood that acting under the influence of gravity there will be a flow of air from the higher to the lower pressure; that is, from about latitude 30° N. and S. toward the Equator. The effect of the earth's rotation on its axis is to cause these winds to blow obliquely toward the Equator from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere. These winds from their relative constancy in direction are known as trade winds.

The origin of the name, according to the Oxford English Dictionary, had nothing to do with "trade" in the sense of "'commerce' or passage for the purpose of trading, though the importance of those winds to navigation led eighteenth century etymologists and even navigators so to understand them."

The trades in their course Equatorward begin in the belts of high pressure, sometimes designated the horse latitudes, and end by giving way to the equatorial calms or doldrums. Further reference to the doldrums will be made later in this discussion.

The North Pacific semipermanent anticyclone.—The annual meandering of this formation is shown in Figure 3. Here again attention is directed to the injunction before expressed that the North Pacific anticyclone should not be thought of as a definite entity, but rather as the monthly average pressure over the ocean in certain geographical positions. In January the center of highest average pressure is found as indicated in the figure; its subsequent monthly mean positions are indicated, and a line

connecting them shows that the center makes a certain amount of westing and northing up to August when it is found in the position indicated; a movement back toward its winter position is then initiated, and the cycle of change begins anew in the succeeding year.

may persist for a day or so, after which they slacken until another impulse is received.

The semipermanent cyclone over the Aleutians attains its maximum geographic extent and intensity in January, as may be seen from Figure 1. It disappears in June and

FIG. 1.—Isobars and prevailing winds, Northern Hemisphere, January

The movement of anticyclones over the Northeast Pacific is mostly in an easterly direction; it must happen then that when fresh bodies of relatively cool air are brought into the western or northern front of an existing anticyclone its wind circulation is increased thereby and there is a distinct response in the northeast trades which is not a disturbing factor between May and September.

Trade-wind boundaries.—The regions where the northeast trades prevail in the North Pacific may be traced in Figures 1 and 2, which show the prevailing wind direction for each 5° square for the months of January and July, respectively.

In winter the Siberian anticyclone is responsible for the northeast winds of the southeast coast of Asia.

The trades are weakest in September, when the northeast monsoon winds of Asia do not exist and the North Pacific anticyclone is rapidly diminishing in strength.

the compass. In other words, winds from the northeast, as recorded on the Pilot Charts, may have been recorded on the ship's log anywhere between NNE. and ENE., and the same discrepancy will apply to other directions.

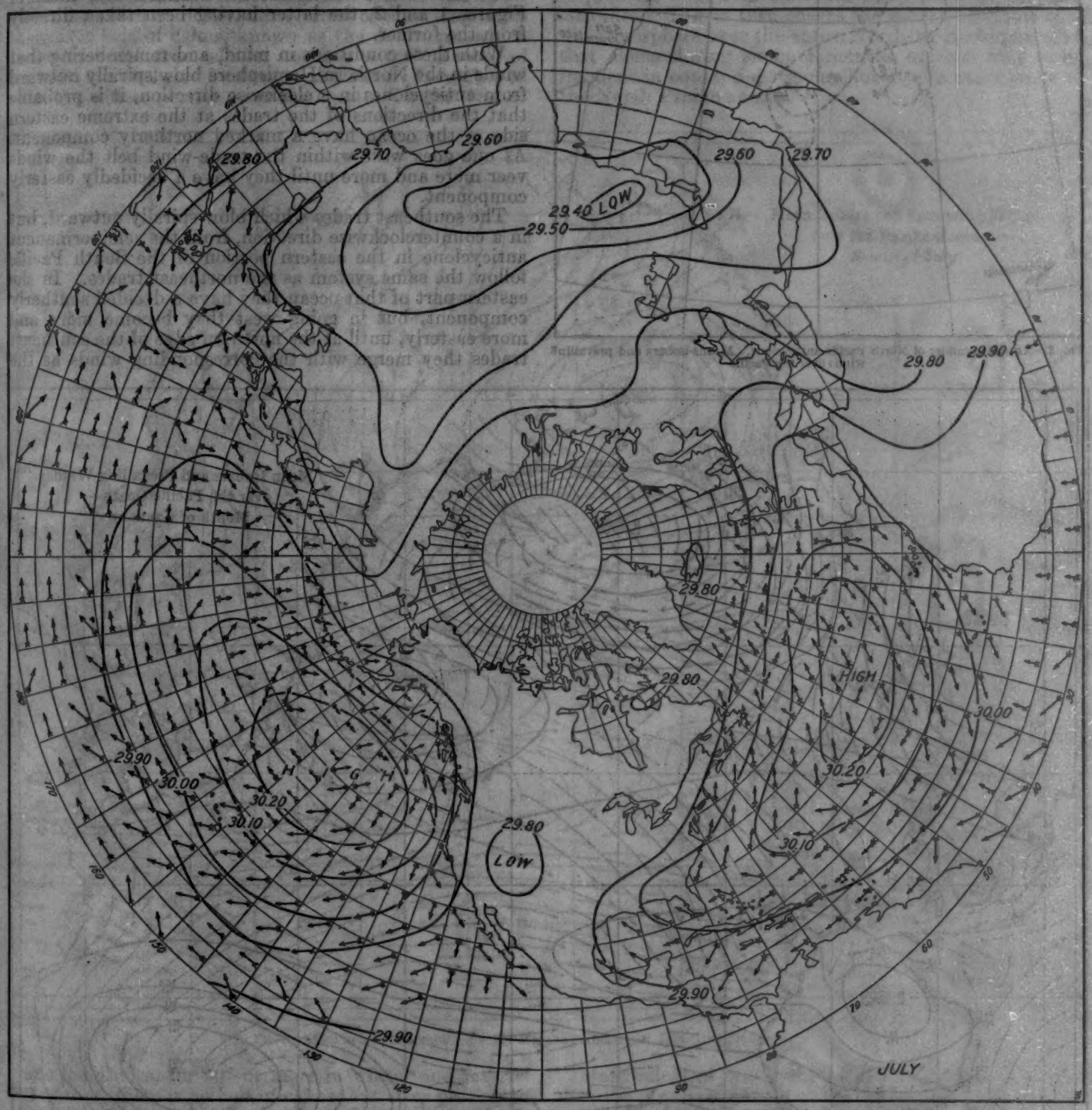

FIG. 2.—Isobars and prevailing winds, Northern Hemisphere, July

Recording trade-wind observations at sea.—Although weather observers on board ship record wind directions to 16 points of the compass, they are published on the North Pacific Pilot Charts on an 8-point scale; therefore a northeast wind on the Pilot Chart may be a wind coming anywhere from 22½° to 67½° on

On account of the wide range between the direction as recorded on the Pilot Charts and those which might have actually occurred, it will be difficult to determine the precise drift of the northeast trades. However, where an east wind prevails in one 5° square and a northeast in the next adjacent 5° square, it is reasonable to

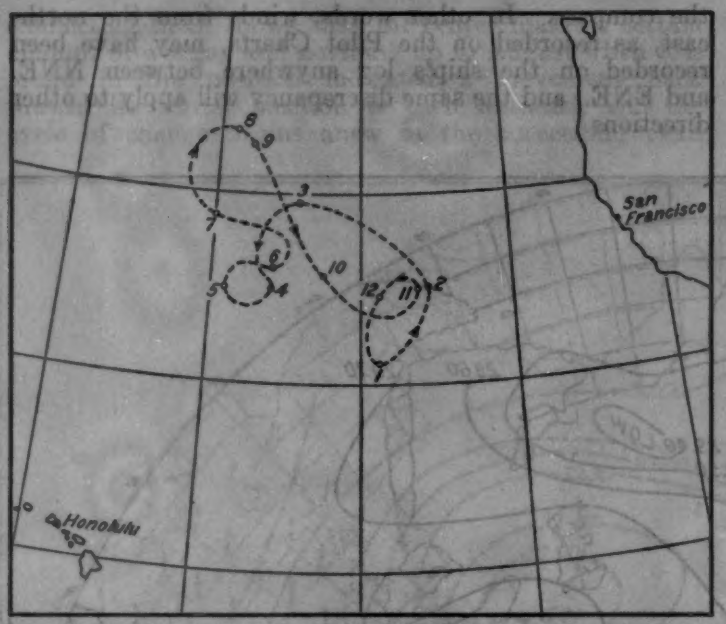

FIG. 3.—Annual meander of North Pacific anticyclone. Means isobars and prevailing winds over the Pacific

presume that the northeast wind had an easterly component and the east wind a northerly component and that the true direction of both winds was not far from east-northeast.

These facts should be considered when examining the wind directions both on the Pilot Charts and those of Figures 1 and 2, the latter having been taken directly from the former.

With these conditions in mind, and remembering that winds in the Northern Hemisphere blow spirally outward from anticyclones in a clockwise direction, it is probable that the directions of the trades at the extreme eastern side of the ocean have a marked northerly component. As one goes west within the trade-wind belt the winds veer more and more until they have a decidedly easterly component.

The southeast trades which blow spirally outward, but in a counterclockwise direction, from the semipermanent anticyclone in the eastern portion of the South Pacific follow the same system as the northeast trades. In the eastern part of that ocean they have a decided southerly component, but in going west they become more and more easterly, until at the northern edge of the southeast trades they merge with the corresponding winds at the

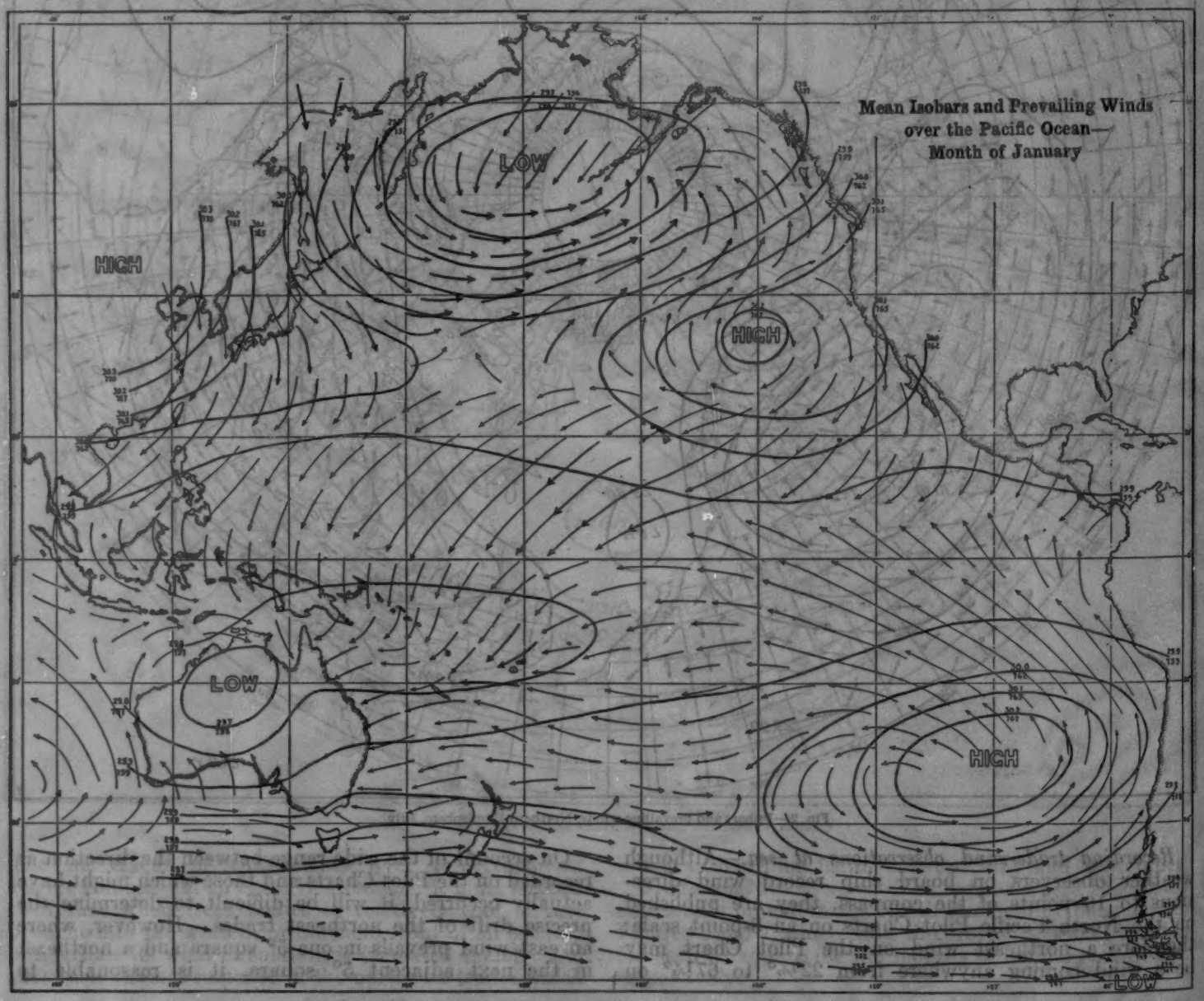

FIG. 4.—Isobars and prevailing winds of the Pacific Ocean (after Werenskiold)

southern edge of the northeast trades. Figures 4 and 5 illustrate these movements.[1]

In summer the northeast and southeast trades of the Pacific, as they approach the Equator, merge at about the 162d meridian of west longitude and in winter at about the 125th meridian, west. East of these longitudes there is a belt of calms, known as the doldrums, which varies in width from almost nothing to 20° or more of latitude. This belt of calms in the Pacific is V shaped with the widest portion near the coast. To the west of these longitudes, for 90° or more in winter and for 20° in summer, there is no belt of calms, but after passing to the west of about 140th meridian of east longitude in winter and the 180th meridian in summer another so-called belt of calms is encountered, which is also V shaped with its apex pointing east and with its base near the Asiatic coast.

One and probably the most important reason for the calm areas being of greater extent on both sides of the North Pacific in summer is due to the absence of the Siberian anticyclone and the cyclone over the Aleutians.

The absence of these formations, which is due entirely to seasonal conditions, causes a more uniform distribution of pressure both over land and water areas of northern latitudes. This in turn checks the general circulation of the atmosphere over the entire Northern Hemisphere, so that calms during summer months are not only most frequent in equatorial regions, but also in other parts of the North Pacific as well.

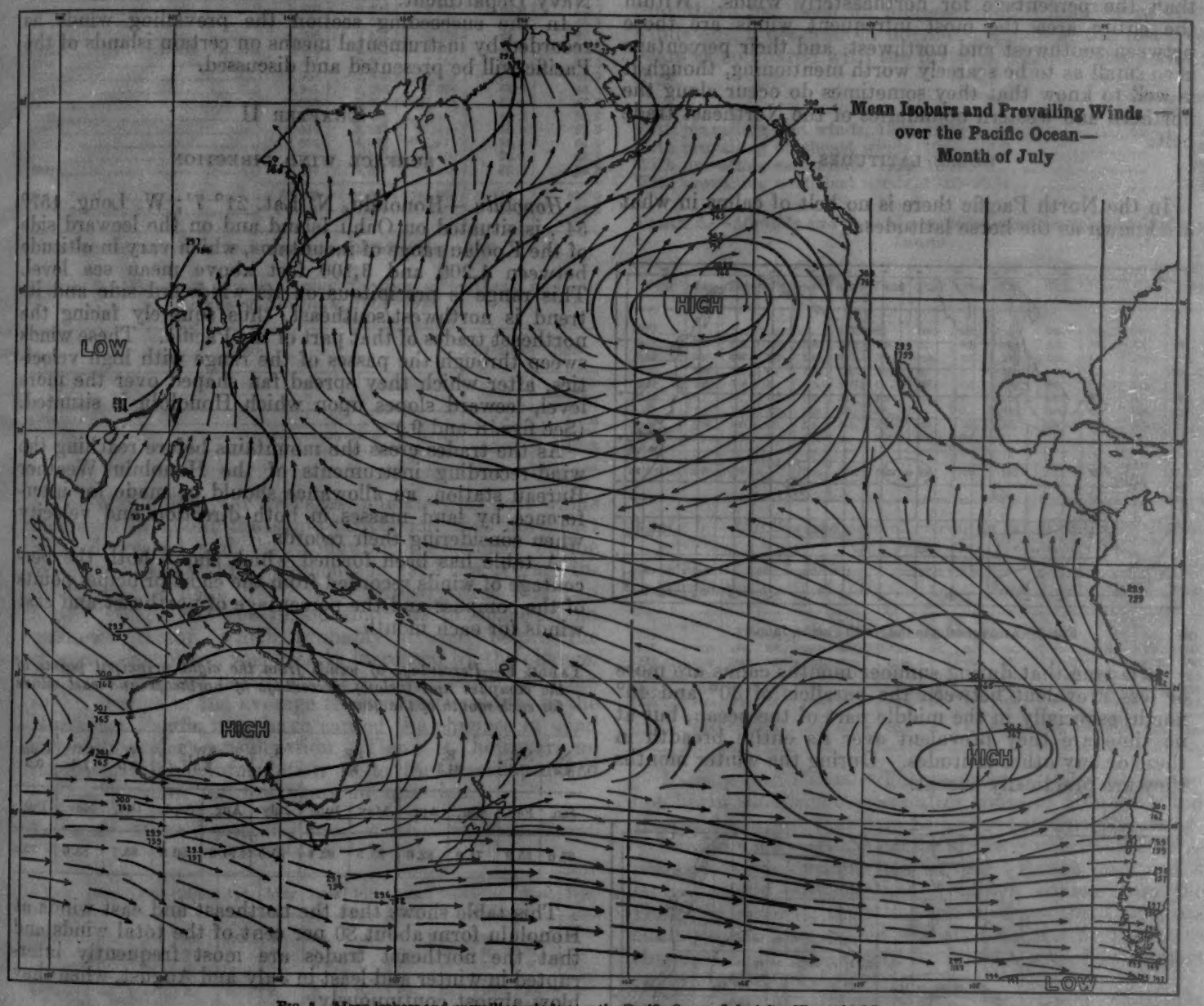

FIG. 5.—Mean isobars and prevailing winds over the Pacific Ocean, July (after Werenskiold)

Meteorological textbooks of North American origin describe a narrow belt of calms, called the doldrums, as existing between the northeast and the southeast trades and extending across both the Atlantic and the Pacific. So far as the Pacific is concerned there is no belt of calms extending across the entire breadth of that ocean. In fact only near the shore ends are there any considerable areas of calms, and these are due to weak pressure gradients.

Constancy of northeast trades.—It can be truly said that they blow continuously from somewhere between

[1] These charts have been taken from W. Werenskiold, "Mean monthly air transport over the North Pacific Ocean."

northeast and east within the central portions of their areas. Along their southern boundaries (in the Northern Hemisphere) there is some overlapping of the southeast trades, which for short periods occasionally prevail in places where the dominant wind is from the east or northeast. On their eastern boundary north winds are frequent, and the prevailing direction there is probably between north and northeast. On their western and northern boundaries winds other than northeast occur quite frequently, but their total percentage is much less than the percentage for northeasterly winds. Within the entire area the most infrequent winds are those between southwest and northwest, and their percentage is so small as to be scarcely worth mentioning, though it is well to know that they sometimes do occur along the northern and western boundaries of the Northeast trade belt.

HORSE LATITUDES

In the North Pacific there is no belt of calms in what are known as the horse latitudes.

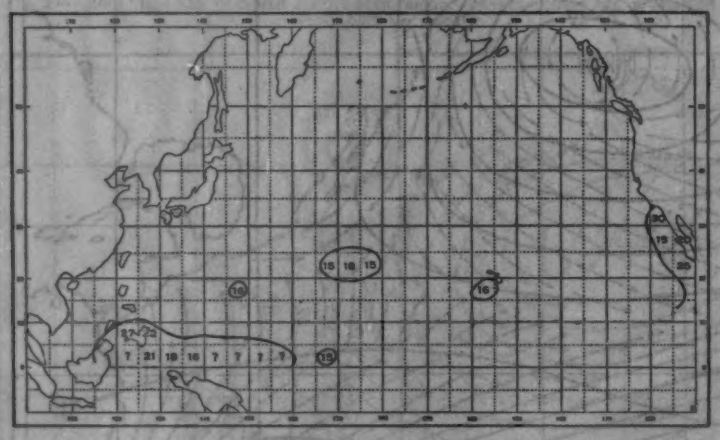

FIG. 6.—Areas of calm in the North Pacific, January

It is true that during summer months calms are more or less prevalent between the parallels of 30° and 40° north, especially in the middle part of the ocean, but at no time are they prevalent over its entire breadth in these or any other latitudes. During the winter months they are practically absent.

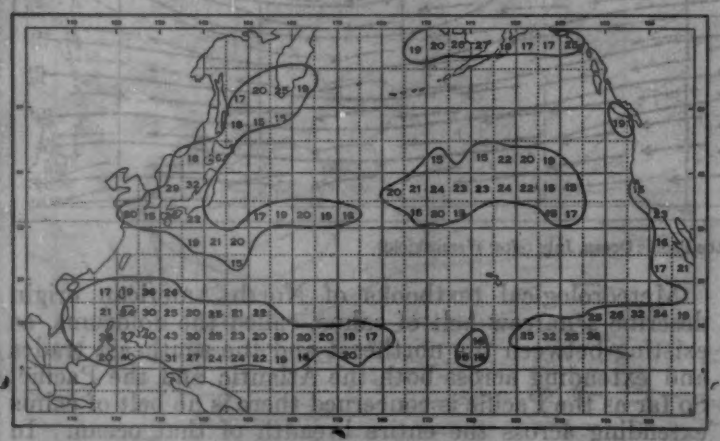

FIG. 7.—Areas of calm in North Pacific, July

In determining the prevalence of calms 15 per cent has been taken as a minimum number in a single month. All areas having 15 per cent or a greater number of calms have been classified as areas with frequent calms.

Figures 6 and 7 show these areas for the months of January and July.

The foregoing presents in outline the essential features of atmospheric pressure distribution in the Northern Hemisphere and the prevailing winds resulting therefrom. The latter are for the most part derived from ships' observations as compiled and published by the Weather Bureau and the Hydrographic Office of the Navy Department.

In the succeeding section the prevailing winds as recorded by instrumental means on certain islands of the Pacific will be presented and discussed.

CHAPTER II

SURFACE WIND DIRECTION

Honolulu.—Honolulu, N. Lat. 21° 7′; W. Long. 157° 54′, is situated on Oahu Island and on the leeward side of the Koolau range of mountains, which vary in altitude between 1,200 and 3,100 feet above mean sea level. This range is precipitous on its windward side and its trend is northwest/southeast, thus squarely facing the northeast trades of that part of the Pacific. These winds sweep through the passes of the range with high velocities, after which they spread fan shaped over the more level, leeward slopes upon which Honolulu is situated. (See figs. 8 and 9.)

As the trades cross the mountains before reaching the wind-recording instruments of the Honolulu Weather Bureau station, an allowance should be made for interference by land masses in both direction and velocity when considering their records.

A table has been formed which shows both the percentage of winds recorded from the eight principal points of the compass and the percentage of northeast and east winds for each month.

TABLE 1.—*Percentage of winds from the eight principal points of the compass and (below) percentage of northeast and east winds for each month of the year*

N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm
4.3	47.5	34.3	3.3	3.3	3.5	2.0	1.4	0.3

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
63.0	65.9	71.0	82.0	83.5	92.4	93.5	94.3	90.8	85.7	83.0	73.6

This table shows that the northeast and east winds at Honolulu form about 80 per cent of the total winds and that the northeast trades are most frequently interrupted in winter and least in July and August, when they blow almost continuously.

The same data in another form are presented in Table 2, which shows the number of hours of northeast and east winds that prevailed at Honolulu for each year of the period 1905–1924, as taken from the automatic records of that station. The wind instruments were given a new exposure when the Weather Bureau office was removed from Young's Hotel to the Federal Building in May, 1922, and from that date onward the duration of the east wind, which had progressively increased at the old exposure as shown by five-year averages, increased at a much more rapid rate, as shown by Table 3.

TABLE 2.—*Number of hours each year the wind at Honolulu was northeast and east, period 1905–1924*

Year	Number of hours from NE.	Number of hours from E.	Number of hours from E. and NE.	Per cent NE.	Per cent E.
1905	5,400	1,711	7,111	75.9	24.1
1906	4,606	2,026	6,726	69.8	30.2
1907	4,735	2,188	6,923	68.4	31.6
1908	4,975	2,569	7,544	65.9	34.1
1909	4,391	2,861	7,252	60.5	39.5
1910	5,495	1,891	7,386	74.4	25.6
1911	4,759	2,463	7,222	65.9	34.1
1912	5,023	2,498	7,521	66.8	33.2
1913	3,907	3,041	6,948	56.2	43.8
1914	4,205	2,571	6,776	62.1	37.9
1915	4,680	2,583	7,263	64.4	35.6
1916	4,664	2,573	7,237	64.4	35.6
1917	3,906	3,847	6,753	57.8	42.2
1918	3,981	3,265	7,246	54.9	45.1
1919	3,825	3,489	7,314	52.3	47.7
1920	3,526	3,631	7,157	49.3	50.7
1921	3,492	3,867	7,349	47.5	52.5
1922[1]	3,094	4,877	7,571	35.6	64.4
1923	2,596	4,554	7,150	36.3	63.7
1924	2,336	4,807	6,933	33.7	66.3
Total	83,288	60,094	143,382	1,162.1	837.9
Average	4,164.4	3,004.7	7,169.1	58.0	42.0

[1] Wind instruments in new location on Federal Building May 1, 1922.

TABLE 3.—*Five-year average annual duration of northeast and east winds at Honolulu, 1905–1924*

Years	Northeast	East
	Hours	*Hours*
1905–1909	4,840	2,271
1910–1914	4,678	2,493
1915–1919	4,211	2,951
1920–1924	2,929	4,303

The above five-year averages indicate that east winds increased in about the same proportion that northeast wind decreased and that following the change in the exposure of the wind instruments in 1922 the average increase was a little more than tripled; thus one can hardly escape the conclusion that the influence of an unknown factor, which probably existed before the change in exposure, was greatly increased by the change. It is nevertheless possible that a progressive, although slight, change in the average track of anticyclones in the Northeast Pacific may have caused the changes in wind direction under consideration. There is, however, no readily available information as to the tracks pursued by anticyclones for the years in question.

TABLE 4.—*Monthly prevailing wind direction at Hilo, Hawaii period 1905–1924*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905	ne.	ne.	ne.	ne.	ne.	ne.	ne.	n.	n.	n.	n.	n.
1906	e.	e.	n.	e.	e.	e.	e.	n.	ne.	n.	n.	n.
1907	n.	s.	n.	s.	s.	n–e.	n.	n.	n.	n.	w.	n.
1908	sw.	s.	se.	n.	ne.	n.	ne.	n.	n.	ne.	n.	n.-nw.
1909	n.	n.	n.	n.	n.	n.	n.	ne.	ne.	ne.	ne.–se.	ne.
1910	ne.	ne.	ne.	ne.	ne.	ne.	ne.	ne.	ne.	------	ne.	ne.
1911	s.	ne.	ne.	ne.	ne.	e.	ne.	ne.	ne.	e.	se.	se.
1912	e.	ne.	e.	e.	ne.	ne.	ne.	------	e.	ne.	se.	nw.
1913	e.	n.	e.	n.	e.	e.	ne.	ne.	ne.	ne.	ne.	e.
1914	n.	s.	n.	n.	se.–s.	ne.	w.	w.	e.–w.	w.	e.–w.	n.
1915	n.	n.	e.	e.	e.	ne.	e.	e.	e.	n.	n.	e.
1916	n.	ne.	ne.	ne.	e.	e.	e.	e.	e.	w.	ne.	se.
1917	ne.	ne.	sw.	e.	e.	e.	e.	n.	se.	e.	e.	ne.
1918	ne.–e.	e.	ne.	s.	se.	------	e.	ne.	ne.	ne.	ne.	ne.
1919	ne.	ne.	ne.	ne.	ne.	ne.	ne.	ne.	ne.	ne.	e.	ne.
1920	e.	s.	e.	e.	e.	ne.	e.	e.	e.	ne.	w.	ne.
1921	se.	e.	nw.	nw.	e.	n.	ne.	n.	n.	e.	n.	n.
1922	ne.	e.	ne.	ne.	ne.	e.	e.	n.	ne.	ne.	ne.	ne.
1923	e.	n.	n.	e.	n.	n.	ne.	e.	n.	n.	n.	n.
1924	n.	e.	n.	s.	e.	e.	n.	n.	n.	n.	n.	e.
Av.	n.–ne.–e.	ne.	ne.	e.	e.	e.	ne.	n.	ne.	ne.	n.	n.–ne.

Surface winds at Hilo.—At this station the observer has no wind vane, although he records daily at noon the direction of the prevailing wind for the preceding 24 hours in accordance with his observations from time to time. A record of this character can not have the same value as one made by automatically recording instruments, as at Honolulu. From the daily records made at Hilo the prevailing direction for the month is obtained. A table of prevailing directions for each month of the period 1905–1924 is given in Table 4.

The record of Hilo surface winds supports the belief that there has been an increase in the number of east winds and a decrease in northeast winds in the last five years as compared with the first five years of the period; thus:

	Number of months
With prevailing east winds, 1905–1909	7
With prevailing northeast winds, 1905–1909	15
With prevailing east winds, 1920–1924	31
With prevailing northeast winds, 1920–1924	12

TABLE 5.—*Monthly and annual prevailing wind direction at Midway Island*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1917	------	------	------	------	ne.	e.	ne.	ne.	ne.	ne.	ne.	sw.	
1918	sw.	ne.	ne.	ne.	ne.	ne.	e.	se.	se.	ne.	ne.	se.	ne.
1919	sw.	sw.	sw.	ne.	ne.	ne.	ne.	ne.	ne.	ne.	ne.	nw.	ne.
1920	nw.	sw.	e.	ne.	ne.	se.	e.	e.	se.	ne.	ne.	e.	ne.–e.
1921	ne.	sw.	e.	ne.	nw.	e.	ne.	ne.	ne.	ne.	e.	ne.	ne.
1922	s.	n.	ne.	ne.	s.	ne.	ne.	e.	se.	ne.	se.	s.	ne.
1923	e.	nw.	ne.	ne.	se.	se.	e.	e.	ne.	ne.	ne.	ne.	ne.
1924	sw.	sw.	se.	ne.	ne.	ne.	ne.	ne.	ne.	ne.	nw.	nw.	ne.
1925	se.	sw.	e.	ne.	e.	sw.	ne.	ne.	------	------	------	------	
Av.	sw.	sw.	ne.–e.	ne.	ne.	ne.	ne.	ne.	ne.	ne.	nw.–ne.	ne.	ne.

TABLE 6.—*Monthly and annual prevailing winds at Guam, Pacific Ocean*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1920	------	------	------	------	ene.	se.	ene.	ene.	ene.	ene.	ene.	ne.	ene.
1921	ene.	ene.	ne.	ene.	ene.	ene.	e.	s.	se.	se.	e.	ne.	ene.
1922	ene.	ne.	ene.	ene.	ene.	nne.	e.	ene.	se.	ene.	ene.	ene.	ene.
1923	ene.	e.	ene.	ene.	e.	e.	ene.	ene.	ene.	ene.	ene.	ene.	ene.
1924	ene.	ene.	ene.	ene.	e.	ene.	ene.	ene.	nne.	ene.	ene.	ene.	ene.
1925	ene.	ene.	ene.	ene.	ne.	ene.	se.	s.	ene,	ene.	ene.	e.	ene.
Av.	ene.	ene.	ene.	ene.	ene.–e.	ene.	e.	ene.	se.–ene.	ene.–ene.	ene.	ene.	ene.

Midway and Guam.—The records at these places do not begin until some years after those of Honolulu and Hilo and can not therefore be utilized in this discussion.

Eureka, Calif.—If the center of the North Pacific semi-permanent anticyclone has on the average occupied a more easterly position than usual, as argued from the Honolulu records, then the winds along the California coast should have veered slightly from the northwest to the northeast. The record for Eureka is used to support or disprove this belief.

The Weather Bureau station at Eureka, Calif., is situated 2 miles distant from the Pacific, the town of Eureka being on an arm of the sea, Humboldt Bay. There are no obstructions to the north nearer than Trinidad Head, 18 miles distant. The wind vane is exposed 89 feet above ground and 137 feet above mean sea level. The record at this location has been kept since January 1, 1911, only. The station was formerly located about 1,000 feet NNW. of its present location and the elevation of the vane above ground and seal level, respectively, was 78 and 104 feet.

It is not thought that this change in the location of the wind vane has in any way affected the record, although

several suspicious circumstances have been developed in the record, as will be referred to later.

Table 7 presents the monthly and annual record of prevailing winds at this station, 1905–1925.

TABLE 7.—*Monthly and annual prevailing winds at Eureka, Calif.*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1905	Se.	Se.	Se.	n.	n.	nw.	nw.	nw.	nw.	n.	Se.	Se.	n.
1906	Se.	Se.	Se.	n.	n.	n.	nw.	nw.	n.	n.	n.	Se.	n.
1907	s.	sw.	Se.	n.	nw	nw.	nw.	nw.	nw.	n.	n.	Se.	nw.
1908	Se.	Se.	n.	nw.	nw.	nw.	nw.	nw.	n.	n.	s.	Se.	n.
1909	Se.	Se.	Se.	n.	n.	nw.	nw.	n.	n.	Se.	Se.	Se.	Se.
1910	Se.	Se.	n.	n.	n.	nw.	nw.	nw.	n.	nw.	Se.	n.	n.
1911 [1]	Se.	n.	n.	n.	n.	n.	n.	n.	n.	Se.	n.	Se.	n.
1912	Se.	sw.	n.	Se.	n.	n.	n.	n.	Se.	Se.	Se.	Se.	Se.
1913	Se.	n.	n.	Se.	n.	n.	n.	n.	n.	n.	sw.	Se.	n.
1914	s.	Se.	n.	n.	n.	n.	nw.	nw.	n.	Se.	Se.	Se.	n.
1915	Se.	Se.	n.	n.	sw.	n.	n.	n.	n.	n.	Se.	Se.	n.
1916	Se.	s.	s.	n.	n.	n.	n.	n.	n.	Se.	Se.	Se.	n.
1917	Se.	Se.	Se.	Se.	n.	n.	n.	sw.	sw.	n.	Se.	Se.	n.
1918	Se.	Se.	Se.	n.	n.	n.	n.	sw.	n.	n.	Se.	Se.	n.
1919	Se.	Se.	Se.	n.	n.	nw.	nw.	nw.	sw.	n.	n.	Se.	n.
1920	Se.	Se.	Se.	n.	n.	n.	n.	sw.	w.	Se.	Se.	Se.	n.
1921	Se.	Se.	n.	n.	n.	n.	nw.	nw.	nw.	Se.	Se.	Se.	n.
1922	Se.	Se.	Se.	n.	n.	n.	nw.	nw.	n.	Se.	Se.	Se.	n.
1923	Se.	n.	n.	n.	n.	n.	n.	n.	n.	n.	Se.	Se.	n.
1924	Se.	Se.	n.	n.	n.	n.	n.	nw.	n.	Se.	Se.	Se.	n.
1925	Se.	Se.	n.	n.	n.	n.	nw.	nw.	n.	Se.	Se.	Se.	n.
Average	Se.	Se.	n.	n.	n.	n.	nw.	nw.	n.	n.–Se.	Se.	Se.	n.

[1] Office moved; first observation in Federal building Jan. 1, 1911.

The method of computing the prevailing wind as given in the above table was changed in 1917; up to that time but two observations per day (8 a. m. and 8 p. m., 75th meridian time) were used, but for subsequent years the direction at each of the 24 hours was taken into account. The prevailing direction for the month was obtained from the daily results. It is doubtful whether the first part of the table is comparable with the second. Since the change in the exposure of the wind vane at Eureka was made 6 years after 1905, the beginning of the record, it is convenient to form 6-year means for the entire period in order to see whether the results prior to the change are in substantial agreement with the results subsequent thereto.

The complete record for the 21 years, giving the number of times in each year that the wind was observed blowing from the north, northeast, etc., is presented in Table 8.

TABLE 8.—*Number of times each year at Eureka, Calif., the wind was observed blowing from specified directions*

Year	Directions								Calm
	N.	NE.	E.	SE.	S.	SW.	W.	NW.	
1905	163	41	43	114	78	91	60	130	8
1906	140	26	37	126	92	114	72	111	11
1907	138	31	36	104	95	97	83	133	14
1908	164	26	45	112	87	76	60	144	15
1909	173	25	37	130	109	64	58	132	4
1910	153	31	42	107	88	70	84	143	3
1911 [1]	215	38	32	134	60	36	69	86	1
1912	160	42	36	147	85	110	70	73	9
1913	184	56	26	136	80	100	60	79	9
1914	148	43	40	151	84	117	53	88	6
1915	175	40	39	137	83	91	72	82	11
1916	196	44	33	132	88	85	66	75	13
1917	176	42	35	129	67	102	69	84	25
1918	178	43	37	131	56	92	43	93	49
1919	150	37	40	128	54	91	43	100	64
1920	182	32	43	120	51	86	50	98	65
1921	165	40	34	117	55	93	56	90	80
1922	185	31	41	105	53	87	52	113	63
1923	227	37	40	113	44	75	40	86	68
1924	178	37	32	97	65	73	53	115	82
1925	178	43	37	105	59	85	48	93	82
Average	174	38	37	123	69	90	60	99	32

[1] Office moved; first observation in new (Federal) building Jan. 1, 1911.

From the above table I have computed the averages for three six-year periods and one three-year period. The results are shown in Table 9.

TABLE 9.—*Wind direction at Eureka, Calif., combined in six-year averages and one three-year average*

	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm
1905–1910	152	30	41	115	91	87	70	132	9
1911–1916	180	44	34	139	81	98	65	79	8
1917–1925	174	38	39	122	55	92	53	99	38
1923–1925	194	39	36	105	56	78	47	98	77
1905–1925	174	38	37	123	69	90	60	99	32

The six-year averages, 1905–1910 and 1911–1916, which include the results previous to and immediately after the change in the exposure of the wind instruments, show variations that point to a local influence effective after the change, that was not operative previous to it, as, for example, the pronounced drop in the number of northwest winds and increase in north winds, etc. No evidence is at hand that would indicate that the two exposures were similar.

It is concluded therefore, that the Eureka record is not faultless.

INFERENCES

What inferences can be drawn from the change in the direction of the trades at Honolulu?

Assuming, for the sake of argument, that the change is real and not apparent, I offer the following: That the center of the highest monthly pressure over the Northeast Pacific, that is, the center of the North Pacific anticyclone, will be found in a more easterly longitude and possibly more southerly latitude than formerly. As a result the barometer at Honolulu should average slightly higher at the end than at the beginning of the period. The first five-year period gives an average pressure of 29.989 inches and the last 29.985 inches; thus there being practically no change at Honolulu the shift of the center of the North Pacific anticyclone must have been to the east, a change that could take place without affecting the pressure at Honolulu; but it would cause a slightly higher pressure along the northern California coast.

The station pressure at Eureka, Calif., 1905–1909, averaged 29.997 and in 1920–1924, 30.036 inches, or an average increase of 0.039 inch, and this difference is allocated to seasons as follows: Winter, +0.092; spring, +0.048; summer, +0.018; and autumn, −0.003 inch. It so happens, however, that there was a similar rise of pressure, not only at Eureka but at nearly all stations from San Diego, Calif., to Tatoosh Island, Wash. The amounts are as follows: Tatoosh, 0.030; Roseburg, 0.038; Salt Lake City, 0.009; Winnemucca, 0.016; Los Angeles, 0.014; Fresno, 0.008; Sacramento, 0.022; Red Bluff, 0.022; at San Francisco there was no change. Thus we are confronted with the evidence that the rise in pressure may have been of continental rather than of oceanic origin. There seems to be no way of deciding definitely, although a consideration of the precipitation may aid to a very slight degree. High pressure and deficient precipitation go hand in hand in Pacific Coast States.

It is generally known that rainfall on the Pacific coast has been deficient for a number of recent years. An examination of the records of 26 stations for the years 1905–1909 shows that the precipitation was generally deficient in those years, but not to so great a degree as in the years 1920–1925. Again the evidence is not definite either for or against the proposition.

Higher temperature at Honolulu.—The north equatorial current flows from east to west in the latitude of the Hawaiian Islands. If the wind which causes this current has changed from northeast to east in the region of Hawaii and thence eastward, of which there is no evidence at hand as to how far to the eastward of Honolulu the change extended, then there should be a slight rise in the temperature of the surface water flowing by Honolulu and consequently higher temperature at Honolulu.

The average annual mean temperature of Honolulu, 1905–1909, is 74.2° and for 1920–1924, 75.0° or 0.8° higher during the last five-year period as compared with the first. Meteorological changes may be due to several factors, and it will require further information before the most probable cause of the higher temperature can be segregated.

Effect of cold upwelling water.—The temperature of the ocean surface water west of the California coast is relatively low owing to the upwelling of abysmal waters. McEwen claims that the effect of this upwelling extends to a distance of 300 kilometers (373 miles) from the coast at Mendocino, in N. lat. 40°, and to a distance of 2,100 kilometers (1,305 miles) off the coast at San Diego. In a personal communication Doctor McEwen informed the writer that "This upwelling is a local phenomenon, dependent upon the Pacific HIGH, although the source of the upwelling water is probably Antarctic. This supply probably slowly drifts northward from the Antarctic along the bottom as needed to supply the deficiency of water due to surface flow away from the California coast by the winds about the North Pacific HIGH.

As previously shown (see fig. 3), the geographic position of the North Pacific anticyclone has a regular seasonal meander, being nearest the California coast in winter and farthest away in summer. So far as known there is no direct relation between the upwelling and the annual migration of the anticyclone. One would expect that the least upwelling along the California coast and naturally the warmest surface water would be experienced in late summer, when the anticyclone had reached its farthest northing.

Ocean surface-water temperatures would be helpful in determining whether the rise in temperature at Honolulu is properly chargeable to increased surface-water temperature.

In this section records of the prevailing wind direction on certain islands of the Pacific in the region of the trades have been presented rather fully. These show good agreement with like records obtained from ships at sea; they show, moreover, for Honolulu and Hilo at least, that there have been slow but progressive slight changes in the general direction of the trades, viz, that the easterly component in these winds has increased, particularly in the later years of the record.

The true explanation of this increase is not at once apparent. It may have been due, as postulated in the discussion, to a change in the average pressure distribution whereby the locus of maximum daily and monthly mean pressure has shifted to a more easterly point on the ocean, or it may have been due to local land-surface obstructions which at present can not be delimited.

CHAPTER III

AVERAGE VELOCITY OF NORTH PACIFIC TRADES

According to the Pilot Charts, the average velocity of the North Pacific trades is force 4 on Beaufort scale, which is equivalent to about 20 miles per hour. In winter and spring there are quite a number of squares on the Pilot Charts having force 5 Beaufort, about 25 miles per hour. Only on three of the squares is a force as high as 6 recorded. Force 6 is equivalent to about 31 miles per hour and it occurs once in April and twice in November. The one case in April and one of the two cases in November are located in the extreme east portion of the trade-wind belt, and the other one in November is located at the western extremity or in the northeast monsoon area of the Asiatic coast.

Increase in velocity toward the Equator.—Milham in writing about the trades states, "As they approach the Equator the velocity steadily increases." This of course does not apply to the western portion of the North Pacific trade-wind belt, as the winds in that region are of monsoon character, having their cause in the Asiatic winter anticyclone. They blow across the Equator and in the midwinter extend as far as Australia. In the true North Pacific trade-wind belt there is a slight tendency for winds to increase in velocity on approaching the Equator, but it is not well defined, probably because of lack of exactness in the record.

While the Weather Bureau station at Honolulu is not advantageously situated as regards the measurement of the true speed of the northeast trades in that part of the Pacific, yet the record has its value and is presented in Tables 10 and 11, the first giving the total travel from all directions and the second from the northeast and east, the trades only.

TABLE 10.—*Total monthly and annual wind movement in miles at Honolulu, Hawaii, period 1905–1924, inclusive*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1905	6,056	4,408	6,302	7,213	6,607	6,211	6,522	6,653	6,400	6,481	5,522	6,070	74,503
1906	7,248	5,212	6,796	6,187	6,633	6,012	6,528	6,577	5,898	5,913	5,376	8,112	76,492
1907	8,626	5,910	7,925	6,982	5,578	5,588	6,422	6,768	5,354	6,065	6,822	5,060	74,098
1908	6,422	5,291	5,332	7,374	6,530	6,452	6,210	5,994	5,741	5,379	5,656	7,666	74,047
1909	6,958	6,216	8,229	5,466	6,535	6,423	6,825	6,537	5,974	6,047	4,870	6,136	76,214
1910	7,322	4,752	6,324	6,609	6,363	6,434	6,210	6,319	4,052	5,362	5,804	6,072	71,713
1911	7,510	6,379	4,734	5,970	5,944	6,440	6,547	5,736	6,092	5,116	6,438	6,301	73,207
1912	5,511	5,955	6,404	7,174	6,460	5,808	5,151	6,125	5,351	6,186	6,003	6,373	72,501
1913	5,192	5,422	5,952	5,247	5,154	5,798	5,983	5,929	5,300	4,259	7,269	5,346	69,851
1914	7,308	3,644	5,752	6,405	6,680	6,443	6,615	7,405	6,840	6,148	6,042	5,208	74,550
1915	6,620	6,258	5,630	6,084	5,276	5,935	5,800	6,443	5,446	6,950	6,657	6,187	72,313
1916	6,648	5,008	7,473	6,431	7,270	6,902	6,110	6,086	5,500	5,440	6,294	6,820	75,982
1917	6,049	5,323	5,694	5,496	4,761	5,399	6,211	5,806	5,388	4,394	5,369	5,644	65,934
1918	5,600	6,214	5,949	7,121	6,046	6,286	7,048	6,172	5,281	6,491	6,767	8,092	77,067
1919	5,860	6,452	6,884	5,351	6,272	5,146	6,356	6,413	6,198	5,541	4,609	5,472	70,554
1920	5,502	5,194	5,657	6,039	4,521	6,377	5,966	6,339	6,309	5,856	5,827	7,063	70,640
1921	8,063	4,664	6,019	7,548	4,565	6,116	6,721	5,893	6,718	5,278	6,317	6,355	74,257
1922	6,821	6,208	6,344	6,330	6,575	5,009	6,662	6,128	5,969	5,058	5,358	4,272	70,831
1923	7,437	3,827	6,191	6,603	6,751	6,662	6,804	5,964	5,385	5,736	6,065	6,380	73,865
1924	5,006	5,089	5,997	4,929	5,122	5,043	6,647	6,740	6,062	6,304	5,315	8,211	67,555
Means	6,442	5,370	6,270	6,482	5,985	6,024	6,369	6,301	5,773	5,710	5,920	6,196	72,359

[1] Velocities reduced to the old elevation from May 1, 1922, to December, 1924, inclusive.

TABLE 11.—*Total monthly and annual movement in miles for northeast and east winds only, at Honolulu, Hawaii, period 1905–1925, inclusive*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1905	3,004	2,308	4,276	6,770	6,307	5,864	5,904	6,571	5,908	6,042	4,361	5,221	63,626
1906	2,926	2,675	2,718	5,244	5,996	5,204	6,465	6,487	5,763	5,349	4,259	4,981	58,067
1907	1,489	3,821	7,171	6,019	3,842	5,098	6,091	6,597	4,557	5,441	6,082	4,302	60,510
1908	5,531	4,040	2,494	6,888	6,376	6,445	6,155	5,701	5,529	4,902	4,915	7,504	66,480
1909	4,480	4,785	7,590	3,919	6,126	6,316	6,614	6,469	5,632	5,277	4,028	5,585	64,825
1910	6,747	3,246	5,708	6,522	5,679	6,333	5,989	6,077	2,575	4,696	5,186	4,547	63,325
1911	4,556	4,620	2,368	5,025	5,563	6,394	6,358	5,523	6,001	4,225	6,136	5,926	62,695
1912	1,920	3,730	5,784	7,067	6,171	5,374	5,034	6,659	4,950	6,118	5,760	6,006	63,827
1913	3,246	2,719	4,887	5,138	3,954	5,221	5,736	4,989	4,734	2,757	6,625	3,730	56,786
1914	5,193	1,627	2,598	4,161	6,033	6,329	6,445	7,274	6,646	5,781	5,140	3,060	60,287
1915	3,966	5,953	3,213	4,804	3,899	5,450	5,702	6,213	5,236	6,318	6,026	4,054	61,423
1916	2,290	3,005	5,380	5,446	7,058	6,763	6,012	5,852	5,232	4,263	6,101	6,011	63,413
1917	3,586	1,360	4,368	4,606	3,716	5,274	6,151	5,690	5,234	3,586	4,642	2,555	50,668
1918	3,185	4,470	5,226	6,074	5,343	5,737	6,979	5,914	4,672	5,992	5,265	7,736	66,593
1919	4,658	5,891	5,270	4,731	5,750	4,772	6,312	6,227	5,404	4,709	3,511	2,882	60,117
1920	1,459	4,649	4,688	4,646	2,148	6,109	5,770	6,229	6,280	5,467	5,610	5,286	58,341
1921	7,434	2,349	4,620	7,043	3,161	5,950	6,675	5,831	6,678	3,980	5,730	5,419	64,870
1922	6,106	5,758	5,425	5,680	6,398	4,568	6,392	6,047	5,618	5,458	4,413	3,539	65,416
1923	5,996	1,745	4,717	5,325	6,240	6,531	6,831	6,626	5,183	5,357	5,714	4,720	63,995
1924	2,625	3,809	5,075	3,380	4,614	4,719	6,606	6,632	6,044	6,154	4,081	2,082	56,913
1925	5,578	2,582	6,141	7,068	6,310	6,438	5,163	7,000	5,005	3,218	5,817	1,413	61,731
Means	4,140	3,682	4,746	5,630	5,270	5,757	6,161	6,124	5,376	5,023	5,205	4,503	61,563

[1] Velocities reduced to the old elevation from May 1, 1922, to December, 1925, inclusive.

The above tables show that there were two 12-month periods of large wind travel, the second of which was preceded by one of small wind movement, thus illustrating a rule of nature that one extreme is quite generally followed by another in the opposite direction. These three periods are segregated in the exhibit below.

Periods	Total, all directions	Per cent of average	Northeast and east only	Per cent
12 months ending—	*Miles*		*Miles*	
October, 1909	78,580	108	71,270	111
March, 1910	78,500	108	69,531	113
January, 1918	65,485	90	50,266	82

Without attempting to assign a cause for the pronounced decrease in wind travel of 1917–18 as compared with other years, it should be recalled that total wind movement the world over is known to vary from year to year and to a degree commensurate with that shown above. The annual wind travel at Eureka, Calif., in the 15 years, 1911–1925, with the same exposure of the wind instruments throughout the period, varied from a maximum of 107 per cent to a minimum of 88 per cent. San Francisco for the same years varied from a maximum of 121 per cent to a minimum of 89 per cent. The year 1917 on the Pacific coast was one of generally small wind travel. Unfortunately data of wind force or travel over the ocean are not available, although the opinion is ventured that there also the wind travel in 1917, as at Honolulu, was less than the average.

The significance of the decrease can not be evaluated, since the phenomenon is one of rather general occurrence. The one fact which stands out in this analysis is that both the increase and decrease are confined to the northeast trades.

On a previous page it was pointed out that the northeast trades are subject to periodical changes in speed, depending upon the passage eastward of anticyclones in the trade-wind belt. It is therefore an allowable inference to associate periods of large wind movement with either a greater number of anticyclones or of greater intensity in individual anticyclones.

The average wind travel at Honolulu, all directions, is 72,859 miles, that of the trades 61,553 miles, a difference of 11,306 miles. In years of large wind travel the difference is less than the average, and in the single year of small travel the difference was 3,911 miles greater than the average, which seems to indicate that the trades diminish more rapidly than winds from other directions and that when pressure distribution is favorable to an increase in the general winds the effect is most pronounced in the trades.

THE WIND MOVEMENT, BY SEASONS

Below is presented the total wind movement in miles per hour for each season for all directions and also for the trades separately. The average velocity in miles per hour has been added. This average was obtained by dividing the average movement by the number of hours in the season, neglecting the small differences that would arise from considering leap years.

Wind movement in miles, all directions—Trades separately

	Spring	Summer	Autumn	Winter
All directions	18,746	18,894	17,403	18,013
Average miles per hour	8.5	8.5	8.0	8.1
Trades	15,666	18,042	15,609	12,236
Average miles per hour	7.1	8.1	7.6	5.7
Winds other than trades	3,080	852	1,794	5,777

The mileage, by seasons, for all directions shows great uniformity, autumn being slightly below the others. Considering the trades separately, however, it is seen that summer is preeminently the season of greatest development of the trades, as elsewhere mentioned. If 10 be taken to represent summer, then the seasonal ratios are spring 9, summer 10, autumn 9, and winter 7.

Table 12 is presented to show the total movement of northeast and east winds for each month of the record, expressed as percentages. The figures 75 for January, 1905, signify that the trades for that month were but 75 per cent of the average for January. In like manner the figures for the annual movement for 1905, 102, indicate that the trades for that year were 102 per cent of the average for all years combined. Other details can be gleaned from the table as may be desired.

TABLE 12.—*Monthly and annual percentages of the total movement of the wind from the northeast and east at Honolulu, period 1905–1925*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1905	75	64	90	120	120	102	96	107	110	120	84	116	102
1906	71	75	57	93	114	90	105	106	107	106	82	110	94
1907	36	107	151	107	73	89	99	108	85	108	117	95	98
1908	133	112	53	122	121	112	100	93	103	97	94	166	108
1909	108	134	160	69	116	110	107	106	105	105	77	80	105
1910	163	91	120	115	108	110	97	99	46	90	100	101	103
1911	110	129	50	89	106	111	103	90	112	84	118	131	102
1912	46	104	121	125	117	93	82	92	92	122	111	133	100
1913	78	76	103	144	75	91	93	81	88	55	127	84	92
1914	126	45	55	74	113	110	105	119	124	115	99	68	98
1915	96	166	68	87	74	95	93	101	97	136	116	99	100
1916	55	84	113	96	134	117	98	96	97	85	117	133	101
1917	86	38	92	82	71	92	100	93	97	71	87	57	82
1918	77	125	110	108	101	100	113	97	87	119	101	172	108
1919	112	104	111	84	109	83	102	102	101	94	67	64	96
1920	35	130	99	82	41	106	94	102	111	109	108	117	93
1921	179	66	97	125	60	103	108	95	124	79	110	120	103
1922	147	161	114	[1]101	121	79	104	99	105	109	85	79	106
1923	145	49	99	94	118	113	119	92	96	107	110	105	104
1924	87	109	107	60	88	83	107	108	112	122	78	46	92
1925	135	72	129	125	120	112	84	114	93	64	112	31	100

[1] Reduced to old elevation from May 1, 1922, to Dec. 31, 1925, inclusive.

AVERAGE HOURLY WIND VELOCITY AT HONOLULU

The average hourly wind velocity at Honolulu for each month of the record, 1905–1924, is given in Table 13, and the same information for the trades is given in Table 14.

The information in the last named has been graphed and the result is presented in Figure 10.

TABLE 13.—*Average hourly wind velocity in miles per hour at Honolulu, Hawaii, period 1905–1924, inclusive*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1905	8.1	6.5	8.5	10.0	9.0	8.6	8.8	8.0	8.9	8.7	7.7	8.2	8.5
1906	9.7	7.8	9.1	8.6	8.9	8.4	8.8	8.8	8.2	7.9	7.5	10.9	8.7
1907	7.6	8.8	10.7	9.7	7.5	7.8	8.6	9.1	7.4	8.2	9.5	6.8	8.5
1908	8.6	7.6	7.2	10.2	8.8	9.0	8.3	8.1	8.0	7.2	7.9	10.3	8.4
1909	9.3	9.2	11.1	7.6	8.8	8.9	9.2	8.8	8.3	8.1	6.8	8.2	8.7
1910	9.8	7.1	8.5	9.3	8.6	8.9	8.3	8.5	5.6	7.2	8.1	8.2	8.2
1911	10.1	9.5	6.4	8.3	8.0	8.9	8.8	7.7	8.5	6.9	8.9	8.5	8.4
1912	7.4	8.6	8.6	10.0	8.7	8.1	6.9	8.2	7.4	8.3	8.3	8.6	8.3
1913	7.0	8.1	8.0	11.5	6.9	8.1	8.0	8.0	7.4	5.7	10.1	7.2	8.0
1914	9.8	5.4	7.7	8.9	9.0	8.9	8.9	10.0	9.5	8.3	8.4	7.1	8.5
1915	8.9	9.3	7.6	8.4	7.1	8.2	7.8	8.7	7.6	9.3	9.3	8.3	8.4
1916	8.9	7.2	10.0	8.9	9.8	9.6	8.2	8.2	7.6	7.3	8.7	9.2	8.6
1917	8.1	7.9	7.3	7.6	6.4	7.5	8.2	7.8	7.8	6.2	7.5	7.6	7.5
1918	7.5	9.2	8.0	9.9	8.1	8.7	9.5	8.3	7.3	8.7	9.4	10.9	8.8
1919	7.9	9.6	9.3	7.4	8.4	7.1	8.5	8.6	8.6	7.4	6.4	7.4	8.1
1920	7.4	7.8	7.6	8.4	6.1	8.9	8.0	8.5	8.8	7.9	8.1	9.5	8.1
1921	10.8	6.9	8.1	10.5	6.1	8.5	9.0	7.9	9.3	7.1	8.8	8.5	8.5
1922[1]	9.2	9.4	8.5	8.8	8.8	6.9	9.0	8.2	8.3	6.8	7.4	5.7	8.1
1193	10.0	5.7	8.3	9.1	9.1	9.2	9.2	8.0	7.5	7.7	8.5	8.5	8.4
1924	6.8	7.4	8.0	6.8	6.9	7.0	9.0	9.1	8.4	8.5	7.4	7.0	7.7
Average	8.6	7.9	8.4	9.0	8.0	8.4	8.6	8.5	8.0	7.7	8.2	8.3	8.3

[1] Reduced to old location from May, 1922, to December, 1924, inclusive; ratio 100 (old) to 117 (new).

(To face p. 221.)

FIG. 8.—Windward (northeast) side of Koolau Mountains looking toward Honolulu, on the other side of the range

FIG. 12.—Wind-instrument exposure at Midway Island

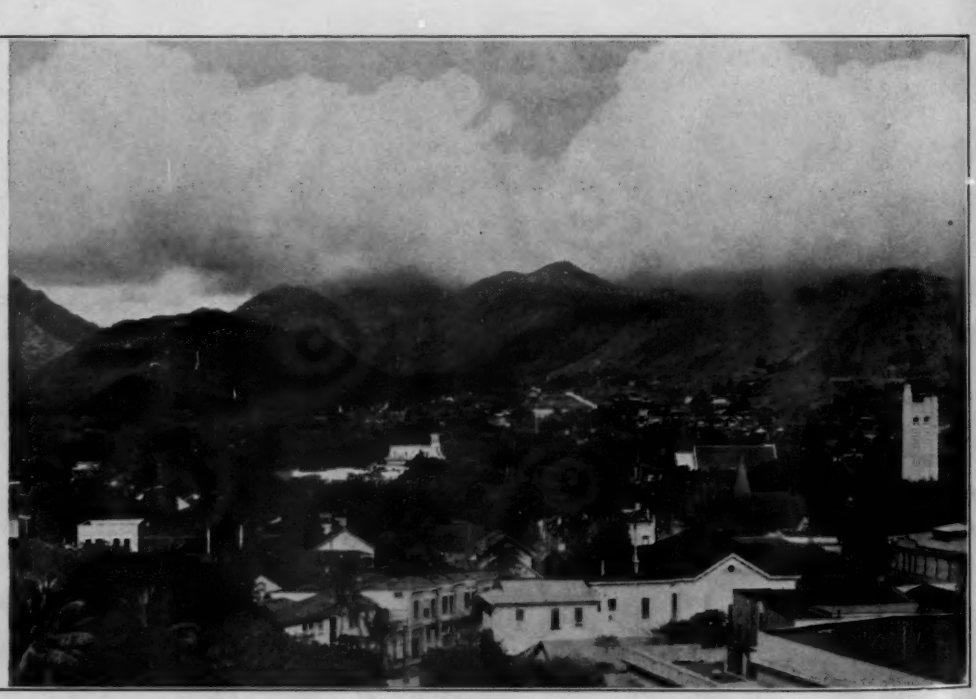

FIG. 9.—Looking east-northeast from Weather Bureau office in Honolulu

UNIV. OF MICH.

TABLE 14.—*Average hourly wind velocity in miles per hour for northeast and east winds only at Honolulu, Hawaii, period 1905–1925, inclusive*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1905	7.6	6.3	8.7	10.5	9.2	8.8	9.1	9.1	9.2	9.0	8.1	8.3	8.6
1906	8.0	7.4	8.6	8.9	9.2	8.4	8.9	8.9	8.3	8.3	7.7	10.2	8.7
1907	4.9	8.5	11.5	10.3	7.3	7.9	8.8	9.4	7.8	8.5	10.6	7.2	8.7
1908	9.3	8.1	6.9	10.7	9.0	9.0	8.5	8.3	8.2	7.7	8.2	10.6	8.8
1909	9.0	10.1	11.5	7.9	9.2	9.0	9.3	8.9	8.6	8.4	7.1	7.7	8.9
1910	10.2	7.7	8.7	9.4	8.8	9.2	8.5	8.9	5.6	7.6	8.5	8.6	8.6
1911	9.9	10.8	5.7	9.2	8.5	9.0	9.2	7.8	8.6	7.1	9.3	9.0	8.8
1912	5.9	8.9	8.8	10.1	8.9	8.3	7.1	8.4	7.5	8.4	8.7	9.0	8.4
1913	7.0	7.0	8.8	11.6	6.9	8.2	8.1	8.0	7.4	5.3	10.4	7.5	8.2
1914	10.3	4.7	6.9	8.5	9.7	9.1	9.3	10.3	10.1	8.5	8.9	7.1	8.9
1915	8.9	9.4	7.5	8.8	7.2	8.6	7.9	8.6	7.6	9.5	9.6	7.4	8.5
1916	7.3	7.0	9.9	9.2	10.1	9.8	8.4	8.4	7.8	7.2	8.9	9.0	8.8
1917	7.8	5.1	8.1	7.8	6.5	7.9	8.5	8.0	7.9	6.0	7.7	6.6	7.5
1918	7.3	9.3	9.1	10.8	8.7	9.1	9.7	8.6	7.4	8.9	9.8	11.1	9.2
1919	8.1	9.8	9.4	7.6	8.8	7.2	8.6	9.0	8.8	7.6	6.4	6.8	8.2
1920	4.9	7.7	8.3	8.3	8.0	9.4	8.3	8.7	8.8	8.1	8.5	8.9	8.1
1921	11.5	5.9	8.9	10.9	5.9	8.6	9.1	8.1	9.4	7.4	9.2	9.2	8.8
1922	10.0	9.8	8.9	9.4	[1]9.1	7.1	9.3	8.3	8.7	8.9	8.1	5.9	8.6
1923	11.2	5.5	8.8	9.8	10.0	9.5	9.3	8.2	7.7	8.1	9.0	9.2	9.0
1924	7.9	8.1	8.9	7.6	7.2	7.4	9.0	9.2	8.5	8.8	8.0	6.4	8.2
1925	9.9	5.8	10.8	10.4	8.8	9.2	7.5	9.6	8.1	6.0	9.2	4.8	8.6
Av. m. p. h.	8.4	7.6	8.8	9.4	8.3	8.6	8.7	8.7	8.2	7.9	8.7	8.2	8.6
Av. m. p. s.	3.8	3.5	3.8	4.2	3.7	3.9	3.9	3.9	3.7	3.5	3.9	3.7	3.9

[1] Reduced to old location from May, 1922, to Dec. 31, 1925; ratio 100 (old) to 117 (new.)

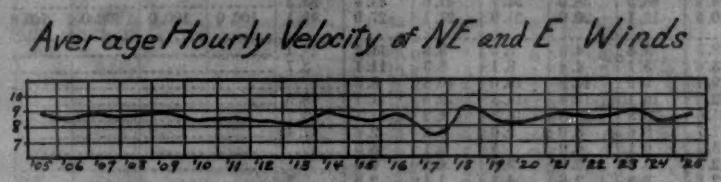

FIG. 10.—Average hourly velocity, northeast and east winds at Honolulu

The outstanding feature of Figure 10 is the steadiness of the trades, barring the years 1917 and 1918, when the largest oscillation in the 20 years occurred.

In winter the trades are more or less suppressed at times, and accordingly winds from other directions have the greater velocity.

In general the uniformity of the trades is not less apparent when the winds from all directions are combined in a single mean, as in Table 13.

DIURNAL VARIATION IN WIND VELOCITY AT HONOLULU

The amplitude of the diurnal variation at Honolulu in January is on the average 4.5 miles per hour and in July 6.2 miles per hour. The increase in velocity begins about 5 a. m. and reaches a maximum between 1 and 2 p. m. in January and between 2 and 3 p. m. in July. These and other details can be drawn from Figure 11.

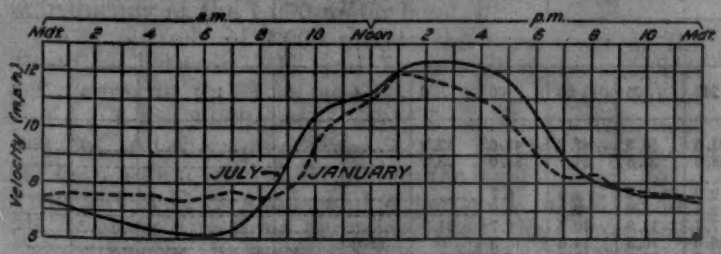

FIG. 11.—Diurnal velocity of wind, Honolulu

Tables 15, 16, and 17 have been compiled from the rather short and somewhat fragmentary records at Midway Island for Hawi Mill on the island of Hawaii (N. lat. 20° 15′ and W. long. 155° 48′), and for Guam. The elevation of the ground is 600 feet above sea level. The elevation of the anemometer above ground is not known. This station is on the windward side of Hawaii.

TABLE 15.—*Average hourly wind velocity at Midway Island*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1920	.....	.....	15.3	14.2	13.6	11.3	13.1	12.9	13.2	11.5	14.6	13.4	.....
1921	17.4	20.4	16.1	18.1	11.8	10.0	17.4	11.7	14.8	16.4	14.1	17.6	.....
1922	14.8	19.4	17.4	14.8	13.5	12.3	13.0	11.9	11.0	14.6	17.8	18.5	.....
1923	17.2	17.2	14.9	11.2	11.2	9.6	8.7	9.1	12.3	11.9	14.7	13.0	.....
1924	13.7	14.2	13.3	14.5	10.4	9.7	13.6	.....	.....	15.8	12.8	18.6	.....
1925	11.5	15.5	14.0	18.8	19.5	11.6	12.9	9.9	9.4	10.8	13.8	.....	.....
Average	14.9	17.8	15.2	15.3	11.8	10.7	11.2	11.1	12.1	13.5	14.6	17.2	13.7

TABLE 16.—*Average hourly wind velocity at Hawi Mill, Hawaii*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1917	.....	.....	.....	.....	.....	9.9	10.0	9.5	9.2	7.2	8.3	7.8
1918	6.9	9.1	7.6	7.6	8.3	8.8	11.2	9.6	8.8	10.6	9.3	12.3
1919	9.6	10.6	9.1	8.0	8.3	8.7	9.8	9.6	8.9	8.3	8.9	9.2
1920	8.0	7.1	.....	8.1	10.2	15.7	14.9	14.4	14.9	11.6	14.6	13.1
1921	15.7	9.8	11.2	14.3	8.3	15.4	16.8	13.7	13.4	10.3	11.4	11.4
1922	13.1	7.5	5.0	4.3	12.5	14.2	14.7	14.9	13.0	10.6	9.4	9.1
1923	11.2	7.5	12.9	11.2	.....	14.0	14.5	12.5	11.7	11.1	11.6	10.3
1924	10.1	10.9	12.3	7.8	10.4	.....	15.2	12.7	9.8	12.3	8.3	10.5
1925	10.8	9.3	12.6	13.7	13.9	16.2	12.9	15.7	10.3	8.9	13.2	8.1
Average	10.7	9.0	10.1	9.4	10.3	12.9	13.3	12.5	11.1	10.1	10.6	10.2

TABLE 17.—*Average hourly wind velocity at Guam, Pacific Ocean*

[Miles per hour]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1920	.....	.....	.....	.....	5.8	5.7	6.8	10.7	6.1	5.0	6.0	8.5
1921	8.5	7.2	8.8	9.9	6.5	7.1	5.3	8.7	5.7	7.3	.....	9.4
1922	.....	.....	8.4	8.5	.....	.....	.....	6.3	6.9	5.7	7.6	8.1
1923	9.6	7.3	9.1	8.6	8.4	8.2	5.6	6.4	8.0	6.0	7.5	7.5
1924	7.6	8.5	8.8	8.1	7.6	6.7	5.9	6.4	5.6	6.3	7.0	7.1
1925	7.9	7.1	8.7	8.8	5.9	5.2	8.3	7.2	8.2	6.5	6.2	8.4
Average	8.4	7.5	8.8	8.8	6.8	6.6	6.4	7.0	6.3	6.1	6.9	8.2

WIND VELOCITIES ON SHORE AND AT SEA

During the summer when the trades are most pronounced at Honolulu, Hawi Mill, and Midway, these stations have 42, 64, and 56 per cent, respectively, of winds of force 4 Beaufort, which is estimated by seamen as the average velocity of the trades. At this season Midway is in the northern portion of the trade-wind zone and Honolulu and Hawi Mill near its center. It may be asked, What is the speed of the trades? Midway is a low, sandy, small island, and the anemometer there exposed should give very nearly true ocean velocities. (See fig. 12.)

Honolulu, as previously stated, is on the leeward side of a high range of mountains, and consequently wind velocities are less than over the ocean, but one would not suspect that they were less than half as much. Hawi Mill, on the windward side of a range of mountains, should receive nearly the full strength of the trades. The greatest velocity at the three stations here discussed is, however, that of Midway, viz, 13.7 miles per hour. That station, it will be remembered, is not at the center of the trade-wind belt. It would appear that an average of 15 to 20 miles per hour would be a fair value for the speed of the trades in the North Pacific.

SUMMARY

It has been shown that the frequency of the northeast trades at Honolulu during quite recent years has diminished concurrently with an increase in the frequency of east winds at the same station and also at Hilo on the island of Hawaii, and a cause or causes have been sought.

A consideration of the meteorological data of the west coast of North America and also of the islands of the Pacific nearest to the Hawaiian group does not lead to definite results.

A study of ships' observations in the North Pacific for the last 25 years is recommended as the most promising field of investigation that may lead to a solution of the cause of the change as above indicated.

FREE-AIR WINDS OVER HONOLULU AND GUAM

By E. A. BEALS

[Meteorologist, U. S. Weather Bureau, retired]

Upper-air observations have been taken by the Naval Air Service at Pearl Harbor, Oahu, Hawaii, since April, 1921. The Pearl Harbor Air Station is in latitude N. 21° 22′, and longitude W. 157° 58′. Not until 1923 was any attempt made to obtain data above 2,100 meters. Since then a few high altitudes have been reached. Owing to interferences by clouds, the bursting of balloons and other causes, free-air pilot-balloon observations are fragmentary, and therefore averages obtained from such records are not wholly satisfactory.

Through the courtesy of the commandant of the Pearl Harbor Naval Station, the records obtained at the air station have been furnished to the Weather Bureau.

HONOLULU: ANNUAL AND SEASONAL FREQUENCIES OF THE VARIOUS WIND DIRECTIONS ALOFT

The result of ascents for the years 1922, 1923, and 1924 are shown in Table 1.

TABLE 1.—*Percentage of wind from different directions at different altitudes above Pearl Harbor, 1922, 1923, and 1924*

ANNUAL

Direction	Surface	135 meters	500 meters	750 meters	1,000 meters	1,500 meters	2,000 meters	2,500 meters	3,000 meters	4,000 meters	5,000 meters	6,000 meters	7,000 meters	8,000 meters	9,000 meters	10,000 meters
Number of observations	1,484	1,453	1,458	1,413	1,302	1,099	787	260	200	55	40	28	5	5	4	4
NNE. to ESE	70.5	83.2	86.6	86.7	83.0	74.2	66.5	58.0	54.7	41.6	44.4	33.3				
SSW. to WNW	5.1	3.2	3.9	4.1	6.1	10.5	12.1	20.0	21.9	27.1	27.9	48.1	100.0	100.0	100.0	100.0
Calm	4.0	2.0	0.5	0.2	0.1											
N	10.0	3.8	1.9	1.3	2.7	3.3	3.8	4.8	5.2	8.3	11.1	11.1				
NNE	15.7	4.9	2.5	2.7	3.3	3.6	5.1	4.4	8.1	8.3	11.1	3.7				
NE	15.0	19.6	16.2	13.2	9.4	9.1	9.9	11.2	10.0	10.4	8.3					
ENE	30.2	41.7	46.1	42.7	35.5	22.2	16.1	15.6	14.3	12.5	11.1	18.5				
E	8.5	15.4	19.1	24.6	30.9	31.6	26.8	18.8	13.3	4.2	11.1	3.7				
ESE	1.1	1.6	2.7	3.5	2.9	7.7	8.6	8.0	9.0	6.2	2.8	7.4				
SE	1.0	1.7	1.6	2.3	2.3	3.1	6.1	4.0	1.4	2.1	5.6					
SSE	1.0	1.3	1.7	1.4	1.8	2.3	3.9	2.8	3.8	4.2	2.8					
S	1.9	1.9	2.2	2.0	2.0	2.8	3.8	2.8	4.3	2.1	2.8	3.7				
SSW	0.9	1.2	1.6	1.3	1.4	2.0	2.2	3.6	2.4	2.1		11.1	25.0			
SW	0.7	1.1	1.1	1.5	1.8	3.0	3.4	4.8	5.2	4.2	5.6	3.7	25.0	50.0	66.7	33.3
WSW	0.5	0.2	0.5	0.6	0.8	1.4	1.9	2.8	4.8		2.8	7.4	25.0	50.0		33.3
W	1.6	0.4	0.6	0.5	1.4	2.7	2.7	4.4	6.2	14.6	13.9	18.5	25.0		33.3	33.3
WNW	1.4	0.3	0.1	0.2	0.7	1.4	1.9	4.4	3.3	6.2	5.6	7.4				
NW	2.8	0.8	0.7	0.9	0.8	2.5	2.7	3.2	3.8	2.1	2.8					
NNW	3.7	1.9	0.9	1.1	1.1	1.3	1.0	4.4	4.8	12.5	2.8	3.7				
WINTER																
Number of observations	293	278	284	281	259	207	155	43	33	9	4	2	1	1	1	1
NNE. to ESE	56.4	74.1	78.2	75.8	70.3	60.4	51.6	30.2	33.4							
SSW to WNW	12.8	5.4	5.7	7.8	12.4	17.4	20.0	35.0	45.4							
Calm	4.4	1.1	0.7	0.4	0.4											
N	13.6	7.6	3.5	2.5	2.7	5.3	3.9	4.7								
NNE	13.6	8.3	3.9	5.0	5.4	5.3	5.2	2.3	6.1							
NE	13.6	16.7	19.4	16.7	11.2	9.2	8.4	11.6	3.0	11.1						
ENE	20.7	25.9	31.0	31.0	26.3	15.5	9.0	9.3	6.1		25.0					
E	7.1	19.8	19.0	17.4	20.5	19.3	16.1	4.7	12.1							
ESE	1.4	1.4	4.9	5.7	6.9	11.1	12.9	2.3	6.1	11.1		50.0				
SE	0.7	2.9	2.5	4.6	5.0	6.3	7.7	2.3			25.0					
SSE	1.7	2.2	3.2	2.8	3.5	3.4	7.7	7.0	3.0							
S	1.7	1.4	3.5	1.8	2.3	2.9	3.9		6.1							
SSW	1.7	2.2	1.8	3.2	3.5	1.9	6.5	9.3	3.0							
SW	1.0	1.4	2.1	2.1	3.9	8.2	7.1	4.7	12.1							
WSW	2.0		0.4	1.4		3.4	1.9	4.7	9.1					100.0		
W	6.4	1.1	1.4	1.1	4.2	2.9	1.3	7.0	9.1	22.2	25.0	50.0	100.0		100.0	100.0
WNW	1.7	0.7			0.8	1.0	3.2	9.3	12.1	11.1						
NW	4.7	1.1	1.4	1.4	1.5	3.4	4.5	9.3	9.6	11.1						
NNW	4.1	4.3	1.4	2.8	1.9	1.0	0.6	11.6	3.0	33.3	25.0					
SPRING																
Number of observations	327	325	330	310	293	247	126	69	60	9	4	2	1	1	1	1
NNE. to ESE	72.4	78.7	79.9	80.0	73.4	61.5	55.5	47.8	45.0	22.2						
SSW. to WNW	3.6	5.1	7.5	7.5	8.8	18.5	23.8	34.7	33.0	33.3						
Calm	5.2	3.0	0.9	0.3												
N	8.6	2.7	3.0	1.3	5.8	2.0	2.4	2.9	6.7							
NNE	7.0	4.0	3.0	4.2	4.1	2.4	4.0	2.9	8.3							
NE	12.8	16.5	14.5	12.3	8.5	7.7	11.9	10.1	6.7	11.1						
ENE	37.6	38.1	39.1	34.5	27.3	16.6	10.3	14.5	13.3	0	25.0					
E	13.8	17.7	21.2	25.5	28.7	26.7	20.6	17.4	10.0							
ESE	1.2	2.4	2.1	3.5	4.8	8.1	8.7	2.9	6.7	11.1	0	50.0				
SE	1.5	2.1	2.1	4.2	2.4	3.2	5.6	5.8	0	0	25.0					
SSE	0.9	2.4	2.1	1.3	3.1	3.2	3.2	1.4	3.3							
S	2.8	3.0	2.7	3.2	3.8	5.7	6.3	1.4	5.0							
SSW	1.5	2.7	3.6	2.3	2.0	3.6	3.2	4.3	1.7							
SW	1.2	1.5	1.5	2.6	2.0	3.6	7.1	14.5	10.0							
WSW	0	0.6	1.5	1.0	1.7	2.4	3.2	5.8	8.3					100.0		
W	0.3	0.3	0.6	1.3	1.4	6.5	7.9	7.2	8.3	22.2	25.0	50.0	100.0		100.0	100.0
WNW	0.6	0	0.3	0.3	1.7	2.4	2.4	2.9	5.0	11.1						
NW	1.2	0.3	0.3	1.6	1.0	4.1	2.4	2.9	1.7	11.1						
NNW	3.7	2.4	1.2	0.6	1.7	1.6	0.8	2.9	5.0	33.3	25.0					

TABLE 1.—*Percentage of wind from different directions at different altitudes above Pearl Harbor, 1923, 1923, and 1924*—Continued

SUMMER

Direction	Surface	250 meters	500 meters	750 meters	1,000 meters	1,500 meters	2,000 meters	2,500 meters	3,000 meters	4,000 meters	5,000 meters	6,000 meters	7,000 meters	8,000 meters	9,000 meters	10,000 meters
Number of observations	459	457	454	439	405	330	250	91	77	29	26	21	3	3	2	2
NNE. to ESE.	83.9	94.1	96.2	97.0	96.6	92.1	80.1	82.5	75.4	55.1	46.1	23.7				
SSW. to WNW.	1.1	0.4	0.4	0	0.2	1.2	4.0	4.4	6.5	17.1	23.0	52.9	99.9	100	100	100
Calm	2.2	1.8	0.2													
N	8.1	0.7	0.2		0.2	1.8	4.3	4.4	5.2	13.8	11.5	9.5				
NNE	18.3	2.2	0.4	0.2	0.5	2.1	5.9	7.7	11.7	13.8	11.5	4.8				
NE	17.0	19.7	14.5	10.9	8.4	9.4	9.4	14.3	14.3	13.8	7.7					
ENE	36.8	51.2	58.6	55.6	45.7	33.3	23.8	22.0	18.2	17.2	7.7	14.3				
E	10.5	19.9	20.8	28.7	39.5	40.6	33.6	28.6	16.9	6.9	15.4	4.8				
ESE	1.3	1.1	2.2	1.6	2.5	6.7	7.4	9.9	14.2	3.4	3.8	4.8				
SE	0.2	0.4	1.3	0.7	1.2	1.8	6.6	1.1	2.6	3.4	3.8					
SSE		0.4	0.4	0.9	0.5	0.6	2.0	2.2		6.9	3.8					
S	1.1	0.9	0.7	1.1	0.7	1.5	0.8	3.3	3.9			4.8				
SSW			0.4		0.2	0.9	0.8	1.1	1.3	3.4		14.3	33.3			
SW		0.2				0.3	1.6		1.3		7.7	4.8	33.3	66.7	100	50.0
WSW							0.8		1.3		3.8	9.5	33.3	33.3		
W	0.2	0.2					0.4	2.2	2.6	10.3	11.5	14.3				50.0
WNW	0.9						0.4	1.1		3.4		9.5				
NW	1.7	0.9	0.2		0.2	0.9	2.0	2.2	1.3		11.5					
NNW	1.7	0.4	0.2	0.2	0.2	0.3	0.4	1.1	5.2	3.4		4.8				

AUTUMN

Number of observations	403	390	390	383	345	315	250	47	39	8	6	3				
NNE. to ESE.	85.5	82.2	86.3	87.7	82.0	74.9	67.6	53.1	46.2	25.0	50.1	66.7				
SSW. to WNW.	5.1	3.1	3.4	3.7	7.5	9.1	9.6	14.8	15.4	37.5	16.7					
Calm	5.0	1.3	0.5	0.8												
N	10.9	5.1	1.8	2.1	3.4	4.4	4.0	8.5	7.7		16.7	33.3				
NNE	21.6	4.6	3.3	2.6	2.6	5.1	4.8	2.1	2.6		16.7					
NE	15.9	21.0	17.2	14.1	9.6	9.8	10.4	6.4	12.8		16.7					
ENE	24.1	45.4	47.9	44.1	35.1	10.4	15.6	10.6	15.4	12.5	16.7	66.7				
E	8.2	9.7	15.6	24.8	31.3	34.3	29.6	17.0	10.3							
ESE	0.7	1.5	2.3	3.1	3.4	6.3	7.2	17.0	5.1	12.5						
SE	1.7	2.1	1.0	0.8	1.4	2.5	4.8	8.5	2.6							
SSE	1.7	0.8	1.8	1.0	1.7	2.5	4.0	2.1	12.8							
S	2.2	2.8	2.6	2.1	1.4	1.9	5.6	6.4	2.6	12.5	16.7					
SSW	0.7	0.5	1.0	0.8	0.9	1.9	0.4	2.1	5.1							
SW	1.0	1.5	1.3	2.1	2.9	1.9	1.2			25.0						
WSW	0.2	0.3	0.3	0.5	1.4	0.6	2.4	2.1	2.6							
W	0.7	0.3	0.8		1.2	2.5	3.2	2.1	7.7		16.7					
WNW	2.5	0.5		0.3	1.2	2.2	2.4	8.5		12.5						
NW	2.2	0.5	1.0	1.0	1.2	2.2	2.4		7.7							
NNW	5.4	2.1	1.5	1.3	1.2	2.2	2.0	6.4	5.1	25.0						

At the surface, 80 per cent of the winds are from N. to E., with ENE. winds 30 per cent of the time. Winds from all the other points have occurred, but none more than 4 per cent of the time.

The most prevalent winds at the 1,000-meter level are between NE. and E., with ENE. winds dominating. The percentage between NE. and E. is 76, and the percentage of ENE. winds is 36. Winds from all the other directions have occurred, but the percentage of any single direction was not greater than 3. The main feature in ascending from the surface to an elevation of 1,000 meters is the decrease in the number of N., NNE., and NE. winds, and the increase in ENE. and E. winds, especially the E. winds, which have gained 22 per cent in frequency at the 1,000-meter level.

At an altitude of 2,000 meters the percentage of the directions between NE. and E. is still dominant, but only amounts to 53 as against 76 at the 1,000-meter level. At the 2,000-meter level, E. winds are the most frequent and their percentage is 27. At this level there has been a gain from the 1,000-meter level amounting to 5 per cent in ESE. winds and 4 per cent in SE. winds. All the other directions have increased their frequency slightly, except those from NNW. which have the same percentage as before. From the foregoing it can be seen that the winds at the 2,000-meter level are more variable in direction than they are anywhere else below that level.

The figures for the 3,000-meter level show the percentages between NE. and E. to be 38, with ENE. winds in the ascendency and their percentage 14, which is only one point above winds from the east. The prevailing winds between NE. and E. have decreased in frequency from 53 to 38 in going from the 2,000-meter to the 3,000-meter level. SE. winds now show a falling off in frequency of 5 per cent, and the principal gains have been made by winds from a westerly quadrant, with their north and south components about equally divided. The variability in direction at the 3,000-meter level is slightly greater than it is in the levels below.

Directions in arcs of 90°.—There are too many factors involved to make practicable a further analysis for each of the 16 compass points, so the data have been assembled into four primary directions as follows: Winds from anywhere between NNE. and E. are considered northeasterly; those between ESE. and S. as southeasterly; those between SSW. and W. as southwesterly; and those between WNW. and N. as northwesterly. This puts in one class all the NE. trade winds, which are the most frequent, and the other groups fit naturally into this arrangement.

In this system of groups their ratios, assuming the group of greatest frequency of winds to be 10, are as follows: NE. 10, SE. 2, SW. 1, and NW. 1.

All the percentages from the surface to the 3,000-meter level are included to obtain these ratios and they show clearly the dominating influence of the northeasterly group over all the others from the surface to 3,000 meters.

Seasonal ratios of the most frequent wind directions aloft.—Assuming that 5 represents the greatest frequency

in wind direction for any one season, the ratios for the different groups for each season are given in Table 2.

TABLE 2.—*Ratio of wind directions for different seasons surface to 3,000 meters*

Quadrants	Spring	Summer	Autumn	Winter
NE	4	5	4	3
SE	4	3	4	5
SW	5	1	2	5
NW	3	2	4	5

Table 2 shows that NE. winds are most frequent in summer, and winds from all other directions most frequent in winter, except SW. winds, which are nearly as frequent in spring as in winter. NE. winds are least frequent in winter and those from other groups least frequent in summer. From this table aviators can ascertain at a glance the seasons when winds from the different quadrants are most likely to occur. For example, SW. and NW. winds are rare in summer, but they do occur quite frequently in winter, and SW. winds are almost equally as frequent in the spring, but NW. winds are more frequent in autumn than in spring.

Altitudes of maximum and minimum frequencies, for four wind directions, by seasons.—Next are presented Tables 3 and 4, showing the altitude of the greatest and the least frequencies of wind in the four groups by seasons, as obtained from all data available between the surface and 3,000 meters.

Tables 3 and 4 show that when their frequency is greatest the NE. winds have a low altitude and those from the other directions a high altitude. It would seem, therefore, that the observations covered fairly well the NE. trade winds, which are most frequent in spring and winter at an elevation of 500 meters and in summer and autumn at 750 meters. They are much less frequent at all seasons at an altitude of 3,000 meters, and probably disappear somewhere between an altitude of 5,000 and 6,000 meters, though during the summer months they may be experienced at higher levels.

TABLE 3.—*Altitude of greatest frequency of winds during each season from surface to 3,000 meters above Pearl Harbor*

Quadrants	Altitude (meters)			
	Spring	Summer	Autumn	Winter
NE	500	750	750	500
SE	2,000	3,000	2,500	2,000
SW	2,500	3,000	3,000	3,000
NW	3,000	3,000	2,500	2,500

TABLE 4.—*Altitude of least frequency of winds during each season from surface to 3,000 meters above Pearl Harbor*

Quadrants	Altitude (meters)			
	Spring	Summer	Autumn	Winter
NE	3,000	3,000	3,000	3,000
SE	Surface.	Surface.	Surface.	Surface.
SW	Surface.	Surface.	Surface.	250
NW	750	750	500	500

Winds from other than a northeasterly direction gain in frequency with altitude, but it is not definitely known at just what levels they reach their maximum frequency. In autumn and winter the records show that westerly winds are not quite so frequent at 3,000 meters as they are at 2,500 meters. This is probably an error due to the scarcity of observations above 2,500 meters. It should be borne in mind, also, that during cloudy weather observations can not be made, and those we have were taken when clouds were insufficient to prevent the balloon from being followed to the conclusion of the run. At Pearl Harbor more cloudiness occurs with westerly than with northeasterly winds.

Turning of trade winds with altitude.—The trade winds here generally turn to the right up to about 2,500 meters, when a reversal in the turning takes place, and they shift back to their former position. This phenomenon is also found in the United States, as noted by Gregg (3): "Near the surface the turning of the winds is generally to the right, no matter what the surface directions may be. * * * With west-northwest winds, through north to northeast or east-northeast, the turning is to the right, but small in amount up to about 1 kilometer, and then changes to the left at higher levels."

The Pearl Harbor record shows that the trade winds continue a slow turning to the right up to about 2,500 meters before they change to the left. The turning probably is due to the persistency of the trade winds and to the enormous field they cover, which is much greater than the United States, where Gregg's information was obtained.

The loss in the frequency of the NE. trade winds above altitudes of 500 and 750 meters is largely compensated by a gain in the frequency of winds from a westerly quadrant. The gain is made by winds having both a northerly and a southerly component of nearly equal proportions.

Neither temperature nor humidity data has ever been obtained in the upper atmosphere within the region of the North Pacific trade winds, so far as known by the writer; therefore the causes that produce pressure gradients that in turn result in this loss of northeasterly and the gain of westerly winds at relatively low altitudes await further investigation before they can be definitely ascertained.

GUAM: FREE-AIR WIND DIRECTIONS

The report received from Guam (latitude 13° 30′ N., longitude 144° 56′ E.) of upper-air observations in the Pacific Ocean is not so complete as the one from Pearl Harbor. The observations were taken by aerologists attached to the United States Marine Corps. The mean monthly resultant wind directions for the period 1921–1924 are presented in Table 5.

The total number of observations is only 568 at the surface. They become gradually less up to the 1,000-meter level, after which they diminish rapidly to 234 observations at 2,000 m. to 95 at 3,000 m. to 47 at 4,000 m. and to one observation at 10,000 m. The fewness of the observations makes the means somewhat uncertain, though the steadiness of atmospheric conditions so near the Equator, and so far from disturbing influences of large land masses, may offset this drawback to some extent.

The data can not be segregated into percentages for individual directions, as only the prevailing winds are given, and not the number of times each direction was observed.

About all that can be said regarding these data is that from the surface up as far as the observations were made the prevailing winds are ENE. for more than half of the time. There were no months with prevailing winds from a westerly quadrant, except one W. at 8 km., one

NW. at 7 km. and one NNW. at 5 km. Two of these occurred in September and one in October. It is quite apparent from these observations, that the antitrades, if there are any at such a low latitude, occur in this portion of the ocean only near the upper boundary of the troposphere.

TABLE 5.—*Mean monthly resultant wind directions at Guam, 1921–1924*

No. obs.	Alt. Km.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
568	Sur.	ene.	e.	ene.	e.	e.	e.	ese.	ese.	e.	e.	ene.	e.	e.
568	0.25	ne.	ene.	ene.	ene.	e.	ene.	e.	se.	ene.	e.	ene.	ene.	ene.
567	0.50	ne.	ene.	ene.	ene.	e.	ene.	e.	ese.	e.	ene.	ene.	ene.	ene.
562	0.75	ne.	ene.	ene.	ene.	e.	ene.	e.	ese.	ene.	ene.	ene.	ene.	ene.
540	1	ene.	ene.	ene.	ene.	e.	ene.	e.	ese.	ene.	ene.	ene.	ene.	ene.
381	1.5	ene.	ne.	ene.	ene.	e.	ene.	e.	ese.	ene.	ene.	ene.	ene.	ene.
234	2	ene.	ene.	ene.	ene.	ene.	ene.	e.	e.	ene.	ene.	ene.	ene.	ene.
137	2.5	ne.	ene.	e.	ene.	ene.	e.	ene.	e.	ene.	ene.	ene.	ene.	ene.
95	3	ene.	ene.	ese.	e.	ene.	ene.	ne.	e.	e.	ene.	ene.	ene.	ene.
47	4	ene.	e.	se.	------	------	------	ene.	e.	e.	e.	ene.	ene.	ene.
20	5	e.	ese.	------	------	------	------	------	se.	e.	nnw.	ne.	ene.	e.
16	6	e.	ese.	------	------	------	------	------	ne.	ene.	ene.	ne.	se.	e.
5	7	------	ese.	------	------	------	------	------	------	nw.	ne.	ne.	ese.	ene.
3	8	------	ese.	------	------	------	------	------	------	w.	------	------	e.	ese.
2	9	------	ese.	------	------	------	------	------	------	------	------	------	e.	ese.
1	10	------	ese.	------	------	------	------	------	------	------	------	------	------	ese.

August is the only month with ESE. and SE. winds between the 250 m. and the 2,000 m. levels. Between the 250 m. and the 1,500 m. levels the winds during May and July are E. while in the intervening month they are ENE. at the same levels. This is a singular phenomenon not easily explained.

Table 5 gives no evidence of a turning of the wind with increase of altitude, although the ESE. and SE. winds outnumber slightly those from NE. and ENE. from the 5,000 m. level up to the limit of observations.

COMPARISON OF UPPER-AIR VELOCITIES AT PEARL HARBOR AND GUAM

These are presented in Table 6. The number of upper-air observations are those already given for these stations.

TABLE 6.—*Average wind velocity (m. p. s.), according to pilot balloon observations taken at Pearl Harbor and Guam*

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Seasons	Surface	250	500	750	1,000	1,500	2,000	2,500	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
Winter	4.3	4.9	6.0	6.6	6.6	6.4	5.6	6.0	6.8							
Spring	4.5	4.9	5.4	5.8	5.7	5.2	5.2	5.0	5.2	7.0	5.2	4.0	(A few scattered observations. See Table 1.)			
Summer	5.2	5.3	6.0	6.8	7.1	6.5	5.7	5.8	5.7	5.8	5.9	6.9				
Autumn	4.5	5.4	6.0	6.8	6.6	5.9	6.0	5.2	5.8	2.6	4.2	5.2				
Annual (m. p. s.)	4.7	5.1	5.8	6.5	6.5	6.0	5.6	5.5	5.4	5.5	5.5	6.4	8.2	10.8	13.3	16.2
Annual (approx. m. p. h.)	10	11	13	14	14	13	12	12	12	12	12	14	18	24	30	36

GUAM

Seasons	Surface	250	500	750	1,000	1,500	2,000	2,500	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
Winter	3.0	8.3	10.2	10.8	10.0	9.1	7.5	7.1	5.6	6.0						
Spring	2.8	7.6	9.1	9.9	10.1	8.5	6.6	6.9	6.5	4.0	(A few scattered observations. See Table 5.)					
Summer	2.6	5.4	6.2	6.7	6.8	6.3	7.1	5.4	4.6	6.5						
Autumn	2.6	6.0	7.0	7.5	7.5	7.2	6.9	6.2	6.1	4.2						
Annual (m. p. s.)	2.9	6.9	8.2	8.9	9.0	7.8	6.9	6.4	6.0	5.9	5.0	6.1	8.0	9.3	10.0	9.0
Annual (approx. m. p. h.)	6	15	18	20	20	17	15	14	13	13	11	14	18	21	22	20

Yearly average wind velocities over Pearl Harbor.—The average yearly wind velocity at Pearl Harbor is lowest, 4.7 m. p. s., at the surface. It slowly increases to 6.5 m. p. s. at 1,000 m., after which it quickly decreases to 5.6 m. p. s. It remains very nearly at this velocity up to 5 kilometers, when another increase occurs. This second increase is progressive up to 8 kilometers, being nearly 1 m. p. s. between 5 and 6 kilometers, nearly 2 m. p. s. between 6 and 7 kilometers, and 2.6 m. p. s. between 7 and 8 kilometers. During the next step up to the 9-kilometer level the increase in velocity is only 2.5 m. p. s., but in going from 9 to 10 kilometers the increase is 3 m. p. s., which gives 16.3 m. p. s. (36 miles) as the velocity at an altitude of 10 kilometers.

Yearly average wind velocities over Guam.—The average yearly wind velocity at Guam is lowest, 2.9 m. p. s., at the surface. It increases rapidly between the surface and the 250-m. level, and then slowly to the 1-km. level. Between the 1 and 5 km. levels the velocity gradually decreases. Above 5 km. the wind steadily increases up to 9 km., where it is strongest, with an average velocity of 10 m. p. s. (22 m. p. h.). At 10 km. the velocity is only 9 m. p. s. (20 m. p. h.). It is probable if more observations were available at this level, instead of a decrease there would be an increase in harmony with that at Pearl Harbor at this altitude.

The change in velocity, first an increase up to 750 or 1,000 meters, followed by a decrease to velocities which continue below those at the 1-km. level, up to an altitude of 6 kilometers before again increasing, is similar to the changes at Pearl Harbor, and probably is universal in the trade wind zone.

Seasonal average wind velocities over Pearl Harbor.—By seasons the average wind velocity at Pearl Harbor, from the surface to the 3 km. level, is strongest in summer, and weakest in spring. From the 1 km. to the 2 km. level, the velocities decrease during all seasons, with the greatest decrease in summer and the least in spring. Between the 2 and 3 km. levels the velocities are the same in spring and summer. In winter there is a slight increase, and in autumn there is a decrease of 2.2 m. p. s. The highest velocity, 7.1 m. p. s., occurs in summer at the 1 km. level, and the lowest, 2.6 m. p. s., in autumn at 4 km.

Up to 2 km. there is no great variation in wind velocity throughout the year, but at altitudes above 2 km. seasonal differences become more marked. At 3 km. the winds in winter are strongest, averaging 6.8 m. p. s., and in autumn they are weakest, averaging 3.8 m. p. s., which makes a spread between winter and autumn of 3 m. p. s. At 4 km. the record for the winter months is missing, but the spread at the other seasons between the highest and lowest is 4.4 m. p. s.; the highest velocity being 7 m. p. s. in spring and the lowest 2.6 m. p. s. in autumn. Other details can be drawn from the table.

Seasonal average wind velocities over Guam.—By seasons the average velocity of the wind at Guam from the surface to 3 km. is strongest in winter and weakest in summer. At Pearl Harbor at similar elevations the winds are strongest in summer, and the fact that they are strongest at Guam in winter is undoubtedly because Guam at that season of the year is largely under the influence of the Siberian anticyclone.

From the surface to 1 km. the summer winds show the least increase, and those of winter the greatest, with the next increase in spring. Between 1 and 2 km. there is a decrease in velocity, except in summer, when the winds are stronger at 2 km. than at the 1 km. During the other

seasons the decrease in velocity is greatest in spring. Between 2 and 3 km. the winds decrease in velocity during all seasons, most markedly in summer, and least in spring. The highest velocity, 10.8 m. p. s., occurs in winter at 750 m., and the lowest, excluding the surface winds, is 4 m. p. s. at 4 km.

General comparison.—The winds at Guam have a smaller velocity at the surface than those at Pearl Harbor but from 250 m. up to and including the 4 km. level they are stronger than at Pearl Harbor. From the 5 km. level to the 10 km. level the Pearl Harbor winds are strongest.

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NOTABLE TORNADOES OF MAY, 1927

[Condensed from reports furnished by George Reeder, H. S. Cole, and A. W. Shilling]

Tornadoes of May 8 and 9 in Missouri.[1]—Severe tornadoes occurred in Missouri on both dates. The one of the 8th was first observed in the southwest part of Camden County, moving thence in a northeasterly direction to Audrain County, a distance of 110 miles, where it disappeared.

The May 9 tornado, or as it doubtless will be known in the future, the Poplar Bluff tornado, because it literally demolished the town of that name, entailed a loss of life of 86 persons in Butler County, 83 being killed in Poplar Bluff. Three hundred were injured and the property loss in Poplar Bluff and Butler County is placed at $2,100,000. This storm was first observed in the southwestern part of Randolph County, Ark.; it moved thence to Poplar Bluff, striking that city at 3.15 p. m. In this city, of from 8,000 to 10,000 inhabitants, less than a dozen buildings remained standing, and even these were badly damaged. After leaving Poplar Bluff the force of the storm seems to have been spent, although strong east and northeast winds were observed some 60 miles to the northeast.

Mr. Reeder recites two rather unusual incidents in connection with these storms. The first was that of a well-constructed farmhouse that was bolted to a concrete foundation with half-inch iron bolts. This house was completely wrecked and two persons were killed in the basement by being crushed by great blocks of concrete torn from the foundation. The second incident was the killing of six persons who were caught in a touring car by the storm that overtook Poplar Bluff.

Arkansas.[2]—No tornadoes occurred in this State on the 8th; but an unusually large number, 11, were reported on the 9th. These storms passed through 25 different towns and communities, 71 persons lost their lives, 449 were injured, and the property loss was estimated at $1,223,000.

The geographic position of the tornadoes of the 8th and 9th are shown on regular Chart No. II at the end of this REVIEW, those of the 8th by black crosses and those of the 9th by black dots.

The tornadoes in Arkansas began a little after 2 p. m. in the northwestern part of the State and developed later and later in the day with distance to the eastward; the last storm was first observed at 4:25 p. m. Details as to these storms will be found in the general table on pages 247–250 of this REVIEW.

Nebraska.[3]—On the 8th between 6 and 6:30 a. m. (105th meridian time) a tornado with a path approximately 34 miles long passed across Lincoln County, Nebr., moving in a direction slightly west of north on a line about 5 miles west of the Weather Bureau station at North Platte. No lives were lost in this storm and the damage was confined to farm buildings. The unusual direction of movement of this storm was probably due to the fact that the cyclonic winds in which it originated were moving from the east and southeast.

[1] Condensed from a report by George Reeder in Climatological Data for Missouri, May, 1927.
[2] Condensed from a report by H. S. Cole.
[3] Condensed from a report by A. W. Shilling.

DISCUSSION

May 8 and 9.—The cyclonic system within which the tornadoes above described occurred was exceptional for the season, particularly because of the low level of the pressure in the center, the track followed by the depression, and its relatively slow progressive movement. See Chart II, track No. IIa.

The pressure gradient over Arkansas and Missouri was not at any time more than fairly steep, nor was it any steeper than that over the adjoining States of Oklahoma, Kansas, and Iowa, in which tornadoes were not reported. Neither was the surface-temperature gradient steep at any time. The 7 o'clock a. m. temperatures over both Missouri and Arkansas on the morning of the 8th were around 70°. There was, however, a steep surface-temperature gradient in the rear of the cyclonic center, especially on the 8th, when the temperature in the cyclone center was 18° to 20° lower than about 200 miles eastward.

The surface wind-shift line on the morning of the 8th was at least 300 miles west of the western border of the State, where tornadoes occurred, and largely because of the northward movement of the cyclone a surface wind-shift line did not pass across either Arkansas or Missouri. The Nebraska tornado occurred in the northeast quadrant and distant about 200 miles from the cyclone center. A pronounced anticyclone was absent on both dates.

In Arkansas the time of occurrence of tornadoes was progressively later and later with distance toward the east. If we can imagine an impulse moving wavelike from west to east, its rate of progression across the State would have been about 25 miles per hour.

The fact that severe tornadoes occurred in Missouri on both dates and in Arkansas only on the 9th is rather puzzling. It might be interpreted as being due to dependence of tornadoes upon conditions of atmospheric instability of more or less local origin which exercises their full influence when, and only when, the presence of a cyclonic system brings about the opportunity of creating an energetic whirl.

The free-air conditions over Arkansas and Missouri may be inferred, approximately at least, by the records of one kite station in Oklahoma and several pilot-balloon stations in neighboring States. These are presented in the

following memorandum by Mr. L. T. Samuels of the Aerological Division:

NOTE

Pilot-balloon observations over Missouri and Oklahoma and kite observations over the latter State show decidedly abnormal and significant free-air conditions on the dates when tornadoes occurred in this section, viz, May 8–9, 18, 24, 27. The outstanding features are:

(1) A marked fall in the free-air temperature occurring coincidently with a rise at the surface and lower levels.

(2) The development or intensification of a temperature inversion immediately above the stratum wherein the marked decrease in temperature referred to in (1) occurred.

(3) An abnormally high lapse rate superimposed on the inversion level referred to in (2).

(4) An excessive increase in wind velocity within the first few hundred meters' elevation.

(5) A veering of the wind with height, usually from southerly at the ground to southwesterly at the level of maximum velocity and occasionally veering until a diametrically opposite direction occurs at about 1,500 meters.

WASHINGTON, D. C., TORNADO OF MAY 14, 1927

By L. T. SAMUELS

A tornado, small but distinct and accompanied by a well-marked funnel-shaped cloud, was observed in Washington, D. C., about 6 p. m. on May 14, 1927. At this time the entire western sky was overcast with Cu. Nb. clouds and a thunderstorm seemed imminent. At Fourth and Channing Streets NE. my attention was attracted by a peculiar movement of the clouds in a small portion of the sky toward the northwest. Although no funnel-shaped cloud had yet formed, a rather violent rotary motion was seen at the lower surface of the clouds in this region. The whole cloud mass, including the rotating area, moved moderately fast from the northwest, and portions of cloud in the rotating area soon protruded downward toward the earth and became funnel shaped. A counterclockwise rotation was clearly observed.

While the funnel increased in length small patches of cloud continued to appear and disappear as if by magic out of the comparatively clear air adjacent to and *below* its tip. These puffs of cloud moved rapidly inward or upward (depending on where they formed) toward the main trunk and usually attached themselves onto the latter. When the cloud was 0.7 of a mile south by west of the writer, its lower end appeared to be about 100 feet above the tree tops which formed the horizon. Its actual height above the ground, however, must have been greater, since it was on the opposite side of an intervening ridge. The patches of cloud rising swiftly upward, seemingly out of the tree tops, toward the main trunk presented an exceedingly striking appearance. It was evident that the air was rushing along both inward and upward and that condensation was occurring with a very small vertical displacement.

As the cloud became more and more pronounced and extended to probably between 200 and 300 feet of the ground the surrounding air became densely filled with scraps of paper, branches, dust, etc., which rose within or very close to the cloud itself and then spread out laterally as the top was approached.

The main trunk at the time of its fullest development appeared to be about 50 feet in diameter. By the time it reached a point to the southwest of the observer it had begun to rise and then gradually became absorbed by the main Cu. Nb. layer from which it protruded. The lower extremity, which lashed violently throughout its journey, seemed constantly to fling off patches of cloud from its tip, while new bits formed and took their place.

The length of the path along which the effects of the tornado were greatest was about one-half mile and its width about 30 feet. It extended from First and Adams Streets NW. southeastward across Prospect Hill Cemetery to Rhode Island Avenue and Second Street NE. The damage consisted of a number of good-sized trees being either uprooted or having large limbs torn off, awnings badly twisted, slate shingles torn from roofs, and several tombstones, approximately 4 by 2 by ½ foot blown over.

Practically no wind was noticed on either side of the actual path. The characteristic noise which usually accompanies tornadoes was not heard by the writer, but others closer to its path described the noise as resembling a "siren." Mr. Albert Kiernan, of 49 V Street NW, saw the funnel-shaped cloud as it approached his home from the northwest, and when it appeared to be over the reservoir at the filtration plant he observed what seemed to be a stream of water rising toward the cloud to a height of 200 feet.

A rather heavy shower of short duration occurred in the vicinity shortly after the tornado passed, but only 0.04 of an inch of rain fell at the Weather Bureau 2½ miles to the southwest. The barograph and thermograph records at the latter place showed only the usual fluctuations characteristic of a thunderstorm. This tornado occurred in the southeast quadrant of a low-pressure area. The 3 p. m. pilot-balloon observation at Washington showed a light surface wind from the south-southeast, becoming southwesterly above 500 meters and increasing steadily to 22 m. p. s. at 2,300 meters, where the balloon entered St. Cu. clouds. An unusually large temperature lapse rate was already evident in the morning, when an airplane observation made at the Naval Air Station, Anacostia, D. C., showed this to be 0.80° C. per 100 m. between the 1,500 m. and 2,400 m. levels.

TORNADO OF MAY 24, 1927, AT ST. JOSEPH, MO.

By W. S. BELDEN

A tornado advanced in an easterly direction through St. Joseph, Mo., from the Missouri River, beginning at about 5:18 a. m. on the 24th. Its destructive path was approximately two blocks wide, but not continuous. Much of the greater part of the destruction to property was in a business portion of the city from Third and Sylvanie Streets nearly due east to High School Hill. Within this distance of two-thirds of a mile many large buildings were seriously damaged, roofs and walls being destroyed. After passing over the hill the course of the tornado was to the southeastward, with considerable damage for several blocks in the residential district, beginning at Sixteenth and Olive Streets. Then after another interval of about half a mile, with only slight damage, the tornado blew down many valuable trees in Bartlett Park, after which it lost energy. For about half a mile on either side of the immediate path of the storm high winds caused considerable damage to shade trees, chimneys, etc.

At the weather observatory, about half a mile north of the path of the storm, the wind attained an extreme velocity of 78 miles an hour from the northwest at 5:18 a. m. This record has been equaled only once since the establishment of the weather station in this city in 1910. For several hours preceding the tornado the temperature ranged from 71 to 68, the wind was light from the southwest, south, and east, and the barometer fell slightly, with reading reduced to sea level, approximately 29.71 inches, for more than two hours preceding the storm. At the time of the passage of the tornado the barometer fell slightly and then rose abruptly 0.07 inch. Excessive rainfall for nine minutes, beginning at 5:18 a. m., amounted to 0.42 inch. Thunder and lightning accompanying the storm were moderate.

Two persons were slightly injured and none killed. A conservative estimate of property damage, made by the city engineer, was placed at about $200,000.

RAIN-BEARING WINDS IN THE FAR WESTERN STATES

By THOMAS R. REED

In "Weather Forecasting in the United States" (3) Henry says: "A simple and very general rule for forecasting the weather in the Pacific Coast States is 'southerly winds bring rain; northerly, fair weather' " (p. 119). Probably all meteorologists, in fact all attentive observers of weather phenomena on the Pacific slope, will concur. So infallible appears the operation of this rule and so extensive is the territory over which it holds sway that desire is naturally aroused to determine the actual proportion of cases to which it applies and to define, and if possible explain the exceptions to it, both for the area in general and for particular regions within it. A practicable way of accomplishing this object was suggested by Von Herrmann's paper entitled "The Rain-Bearing Winds of Atlanta, Ga." (1), in which rainfall percentages were diagrammatically represented for each of the eight compass points and for the various months of the year. Weather Bureau stations of the first order within the San Francisco forecast district, which comprises the States of Washington, Oregon, California, Nevada, and Idaho, were asked to contribute these statistics for the 10-year period 1916–1925, and graphic representations developed from their tabulations are reproduced herewith. The only station submitting data based on a shorter period was Spokane, where only 5 years' record was available. Diagrams for each of the 21 stations and for each of the 12 months have been drawn after the Von Herrmann plan, although involving a somewhat dissimilar development of the data.

While diagrams for all the months reveal facts of interest, those portraying the rain-bearing winds of the wet season are most significant. It is evident that due to the shortness of the period for which means were computed, only the data for the rainy season can be relied upon for conclusions. Rainfall during the dry season is so infrequent and relatively so light that, to be representative, means would have to be obtained from an exceedingly long period of observations; longer, in all probability, than any offered by available records. This fact should be borne in mind while inspecting the diagrams, as otherwise very imperfect impressions may result. To cite one case in which this defect is well illustrated, take the San Luis Obispo figures for the nearly rainless month of June. The percentages show northwest to be the rainiest quarter, but inspection of the detailed record reveals the inadequacy of the data, as during the 10-year period there was a total rainfall of only 0.24 inch for all directions, of which 0.08 inch happened to occur while the wind was in the northwest. Another example is furnished by the San Jose table. In this case the meteorologist who supplied the data sought to modify the obvious inconsistency of the dry-season percentages by extending the record to include a 20-year period, and yet we find the maximum rainfall in July occurring with a northwest, or fair weather, wind. Here the limitations of even a 20-year mean for the dry months are clearly illustrated, since the detailed record for July contains a 20-year total of only 0.11 inch, of which 0.08 inch fell during the time the wind was northwest. Similar defects could be pointed out in most of the tables so far as summer conditions are concerned, although the errors become less egregious as we go north along the coast and the amount of summer rainfall proportionately increases.

Obviously, too, with so pronounced a dry season it was impracticable to follow Von Herrmann's method of computing percentages on the basis of annual means and percentages based on monthly means were employed in preference. It was thought that labor would be lessened without material sacrifice of accuracy if station normals for the various months were used instead of actual means for the 10-year period, and most of the station officials made their computations in this way; but a few, feeling that the results thus obtained were misleading, computed means for the particular period involved and secured percentages therefrom. Emphasis must be given to the fact that the percentages refer to the amount of precipitation and not to frequency of its occurrence.

The outstanding fact established by the tables and diagrams is the preponderance of precipitation with south winds. The most casual scrutiny of the data makes this plain. At some stations there are strong southeast and southwest components, and at a few stations one or the other of these components exceeds the southerly

direction in the amount of precipitation associated therewith. In most cases, it is believed, the deviation from south or southwest can be accounted for by some orographic explanation. Indeed, such explanation extends to nearly all phases of the diagrams where rains of any considerable amount are found occurring with other than a southerly wind. The exceptions will be found only to confirm the rule that, given a reasonably free exposure, the rain-bearing surface winds are preponderantly from southerly quarters.

As an initial example of such deviation the case of Tatoosh Island, Wash., may be cited. Situated at the entrance to the Straits of Juan de Fuca, it is peculiarly exposed to the east winds which are often found sweeping through them at times when southeast of south winds are blowing at other points on the Washington coast. Not infrequently when this is the case cloud observations at Tatoosh Island show the existence of southeast or south winds at a comparatively low level in the free air above. No other diagram depicts an easterly component which approaches in value this one so conspicuous in the Tatoosh Island diagram, or it might better be said, the existence of an easterly current with rainfall is a marked rarity at the great majority of stations, Tatoosh Island being the most notable exception.

This infrequency of precipitation with east winds in the far West is a phenomenon worthy of special note. While an east wind anywhere in this region denotes an offshore and therefore a relatively dry wind, this by no means dismisses it as a factor in the rain-making process. Both Bjerknes and Shaw, whose situation on a west continental front in the North Temperate Zone makes their observations of peculiar interest to the student of weather forecasting in the North Pacific States, postulate an easterly current or "wedge" over which the rain-bearing southerly wind must ride in order to precipitate its moisture. Such being the case in western Europe, one would naturally expect to find its counterpart on our own western shores. A noteworthy dissimiliarity is presented by our diagrams in this respect, however. Not only is the occurrence of east winds at times of rainfall an abnormality, but its appearance in any of the diagrams may be accounted for, as a rule, by some orographic explanation rather than by the assumption of its existence as a function of the usual cyclonic circulation. This is obviously the case at Tatoosh Island, of which mention has been made, and it is likewise true of winds at other stations farther south.

At North Head and Portland, for example, a small percentage of easterly wind is found, probably induced by the proximity of the great Columbia River gorge, which forms an east-west gap in the Coast and Cascade Ranges. Another station showing a rather prominent easterly component is Fresno. The occasion for this is not altogether obvious, although it may well be found in the disposition of the foothill areas to the north, which probably have a deflecting effect on the predominant rain wind, which is southeast, The hills may cause the rain-bearing wind to assume at times an east-west trend over parts of the upper San Joaquin Valley.

A conspicuous easterly arm is found in the Spokane diagram, but although explanations based on topographic features of the country might account for it, conclusions drawn from the data would be unsafe due to the short period (five years) covered by the record, together with the fact that much of the data are from interpolated records during the winter season, since at that time the recording rain gauge is not functioning.

In the consideration of easterly rain winds perhaps the diagrams which present the most anomalous outlines are those for Los Angeles and San Diego, particularly the former. Flanked by high mountain ranges to the leeward and possessing an unobstructed marine exposure, the region around Los Angeles might be expected to offer ideal opportunity for the occurrence of rain winds from the oceanic or southwesterly quarter. Instead we find a very pronounced opposite component, not only easterly but northeasterly winds being conspicuous in nearly all months, but exceeding other directions in a majority of cases. It is certain that any explanation of this state of things must reside in the configuration of the terrain. This region presents the most radical orographic contrasts to be found in the United States. The mountains rise sheer from base elevations but little above sea level to heights varying between 8,000 and 12,000 feet. The deflective effect produced in gradient winds by these colossal barriers could not be other than profound, although it might not be supposed that a complete reversal of direction would result. It seems probable that at both Los Angeles and San Diego the relation of mountains and plain necessitates the formation of some sort of eddy conforming in a general way to the axes of the principal ranges. Those flanking Los Angeles lie east and west, while those back of San Diego lie north and south, a disposition which may serve to explain a horizontal eddy in the lower atmospheric levels, greatly complicated in its details by the extremely irregular character of the terrain as a whole. At San Diego, it will be noted, although considerable rain occurs with east winds, the predominating rain wind is from the south during all the wet months, whereas at Los Angeles northeast rain winds predominate during the wet months and southerly rain winds are inconsiderable.

But if east and northeast winds at times of precipitation are exceptional, their insignificance is scarcely greater than that of winds from north and northwest quarters, and stations which show this idiosyncrasy are exceptional enough to require individual comment. Two such stations are found in the intermountain region, namely, Baker and Boise. At Baker the northwest component is especially noteworthy, very nearly equaling the preponderant winter direction, which is southeast, and in spring and summer exceeding all others. At both stations the contour of the land would seem to account adequately for the unusual amount of precipitation with northwest winds. It will be remarked that winds of cyclonic origin—that is to say, rain winds—at both stations conform in direction to the main axial line of the respective valleys, being from one of two opposite directions, northwest and southeast.

This subserviency of wind direction to the contour of the valleys is equally apparent in California, where the behavior of rain winds in the Santa Clara, Sacramento, and San Joaquin Valleys well illustrates the point. In the Sacramento Valley, in which Red Bluff and Sacramento are located, there is relatively little rain with northwest winds, since such winds are down-slope. In the San Joaquin Valley, and less pronouncedly in the Santa Clara Valley, represented by the stations at Fresno and San Jose, respectively, the reverse is true, northwest winds at these stations being up-slope winds and consequently contributing a moderate proportion of moisture.

A feature common enough to the diagrams to warrant remark is the increase of rain percentage with northwest winds in the spring and fall of the year. Note will be taken in particular of the relative insignificance of the

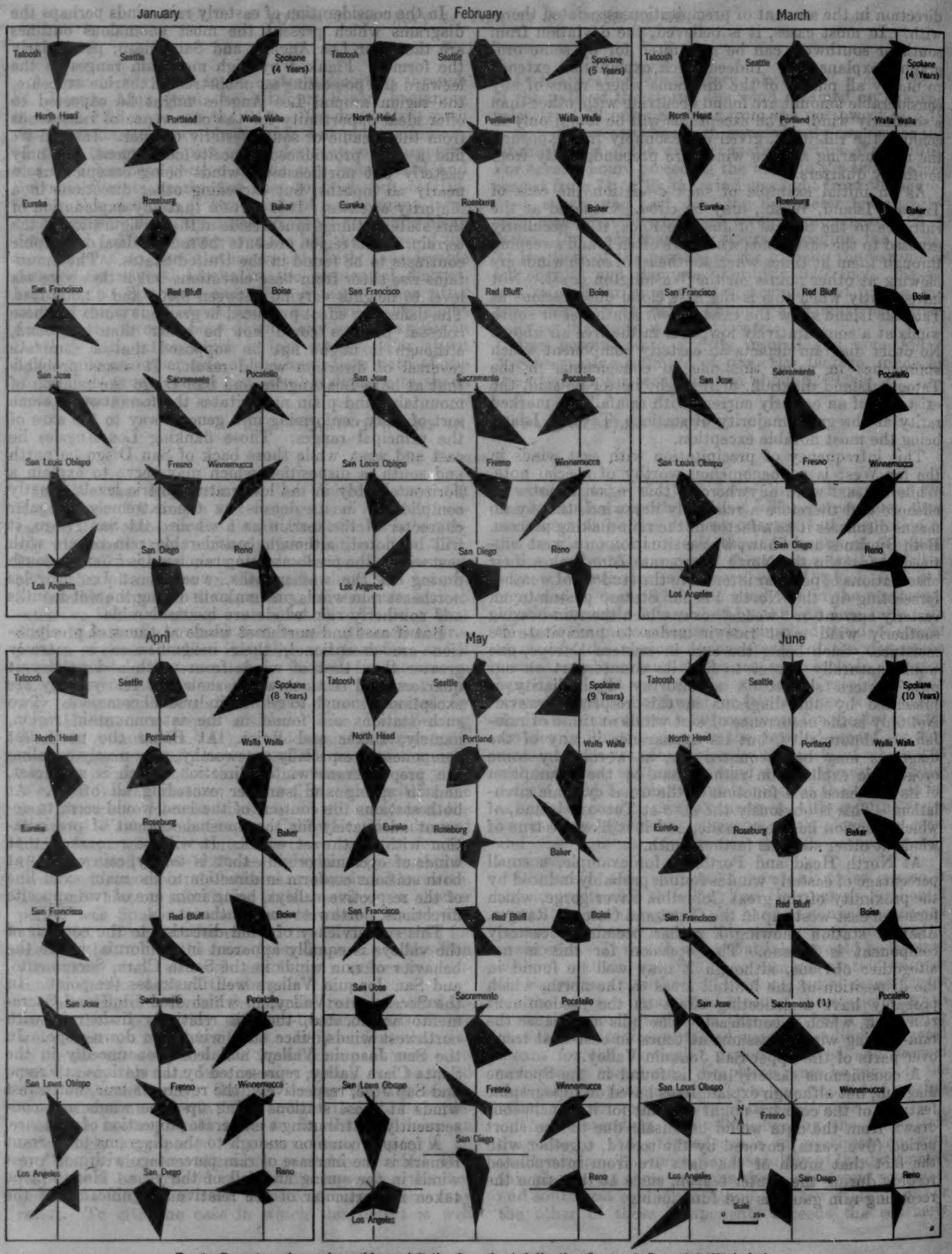

FIG. 1.—Percentage of normal monthly precipitation for each wind direction, January to June, 1916–1925, inclusive

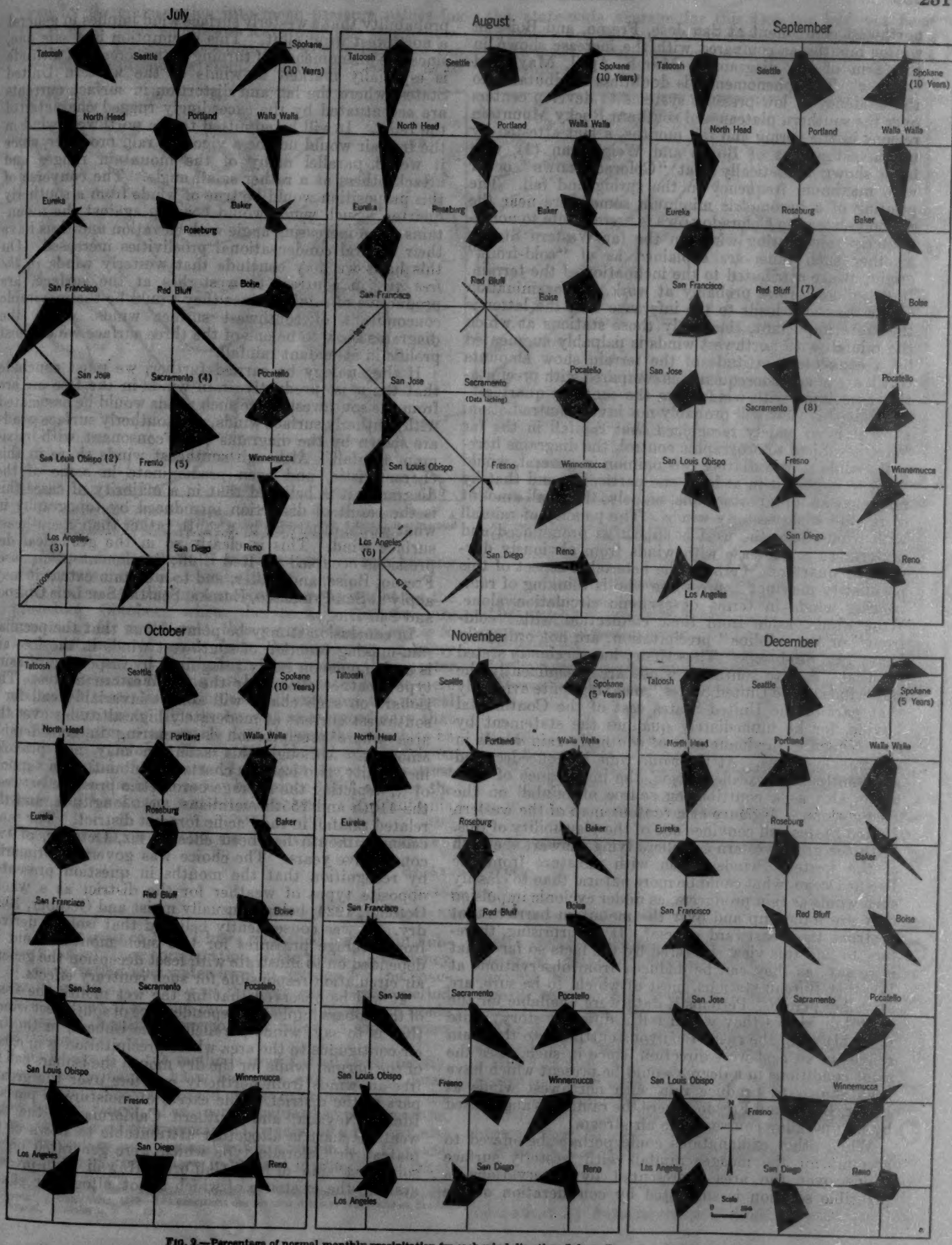

FIG. 2.—Percentage of normal monthly precipitation for each wind direction, July to December, 1916–1925, inclusive

northwest component at San Jose, Fresno, and Boise in winter months as compared with the increase shown in this arm of the diagram in March, April, May, and October. This phenomenon is doubtless attributable to the tendency of low-pressure systems to develop centers over the southern plateau and southern Rocky Mountain regions in the spring and fall months, a fact attested by the investigations of Bowie and Weightman (2), who have shown statistically that "Colorado LOWS" occur with maximum frequency in the spring and fall. The positing of a barometric minimum somewhere near the region assigned to Colorado LOWS is prerequisite to northwesterly rain-bearing winds in the far Western States, whether such rains are explained as of "cold-front" origin, or are attributed to the inclination of the terrain. Both influences are probably at work, but examination of the diagrams leads to the inference that the latter is the more important, since only those stations at which the rainfall with northwest winds is palpably augmented by a convenient attitude of the terrain show amounts which are of any consequence as compared with precipitation associated with winds from the contrary quarter.

While this view will probably not invite contradiction, since it is so widely recognized that rainfall in the far West is subject to orographic control, the diagrams herewith, while substantiating this opinion in general, would seem to oppose it in at least one particular, and that by no means an unimportant one, namely, the small amount of rainfall with westerly winds. The paucity of rainfall with winds from the west is almost as pronounced and uniform as is the case with winds from obviously dry-weather quarters. Perhaps the heterodox aspect of this peculiarity may not impress one who is thinking of rain-bearing winds in terms of cyclonic circulation alone. West winds, aside from their connection with "cold-front" or "squall-line" precipitation, are not ordinarily heavy rain producers. Thus Henry has succinctly stated (3) that "east to southeast winds are preeminently the rain winds of the United States," meaning quite evidently that part of the United States east of the Continental Divide, for he immediately qualifies the statement by specifying the predominance of southerly rain winds in the Pacific States. At the same time he concedes, and apparently with excellent logic, the importance of west winds also as a contributing source of rainfall on the Pacific slope. A glance at a contour map of the western United States will convince one of the plausibility of this. With the great western cordillera lying athwart the path of the westerly winds, laden with moisture from the Pacific Ocean, what could be more natural than to classify such winds as rain producers, as under cyclonic impulsion they are forced up and over the mountain barriers that obstruct their eastward course? It is surprising, therefore, to find this view shattered by the facts so far—that is to say, as they can be deduced from observations at Weather Bureau stations, most of which, to be sure, are at valley points. Perhaps if data were available for the mountain slopes they would tell a different story; quite probably so in the case of canyons cutting into the main ranges in an east-west direction, since in such cases the same conditions in a degree would be present which have been shown to produce rain with northwest winds at Baker, Boise, and Fresno, where the rainfall is augmented by an up-valley course of the air stream.

While other explanations could perhaps be offered to account for the meager rainfall with westerly surface winds over the area represented by observations, a plausible solution is suggested by consideration of the probability that a westerly surface wind implies in general a northwest wind aloft. This assumption is a safe one, since the phenomenon of turning with increase of altitude is especially marked in winds of the western United States, where the lag and distortion in surface currents are accentuated by the exceedingly rugged character of the relief. It will be admitted that a northwest wind in the free air would not be a vigorous rain producer, since it would parallel many of the mountain ranges and attack others at a rather small angle. The converse of this proposition would be true of winds from a southerly quarter. Such winds would bear up against the mountains at an increasing angle with elevation and thus have their natural condensational proclivities increased. On this basis we may conclude that westerly winds *in the free air*, in contrast to westerlies at the surface, are productive of rainfall, since they would be the inevitable concomitant of southwest surface winds, which the diagrams show to be one of the three surface winds most prolific in attendant rainfall.

If the analogy be carried further, we must conclude that the most productive rain winds in the free air are from the southwest, since such winds would be associated with southerly surface winds, and southerly surface winds are shown by the diagrams to be consonant with maximum rainfall. Although southeast winds share in this characteristic, and even predominate in some of the diagrams, it is believed that in a majority of cases this is the result of distortion introduced by topography in what would otherwise be a south rather than a southeast surface wind. This is clearly so in the geological depressions occupied by Red Bluff, Sacramento, San Jose, Fresno, Boise, and Baker, and to a certain extent it may apply at San Francisco, Eureka, Seattle, San Luis Obispo, and San Diego.

In conclusion it may be pointed out that the peculiar rain-making function of southwest winds in the free air is a phenomenon easily recognized by inspection of rain-type weather charts for the far Western States. The isobars on such charts will almost invariably call for a southwest current at moderately high altitudes over the area where precipitation is occurring in considerable amounts. Although this assertion may not provoke incredulity, two isobaric charts are submitted in support of it, depicting the average barometric pressure between the 110th and 155th meridians, west longitude, and the related rainfall in the Pacific forecast district. The same calendar month has been chosen, viz, October, of two consecutive years. The choice was governed primarily by recognition that the months in question presented opposite types of weather for the district as a whole, October, 1924, being unusually moist and October, 1925, dry. It was consequently believed that isobars derived from average pressures for two such months could be depended on to illustrate with least deception the general air circulation responsible for such contrary effects.

It will be observed that for the wet month the trend of the isobars implies a preponderance of southwest winds; that is to say, winds paralleling the isobars, in the free air contiguous to the area where precipitation is in excess of the normal, while for the dry month the isobars call for free-air winds from northerly quarters over the greater part of the district. The excess of moisture in parts of Idaho, Nevada, and southern California on the dry-weather chart is altogether attributable to LOWS of the plateau or Colorado type which were generated on the southeast side of the California-Hawaii high-pressure system, the existence of which is not altogether effaced

even by their absorption into mean pressure values for the month. The significant feature of this chart, however, is the abnormal position and axial attitude of the oceanic high-pressure system, which is so disposed as to imply the displacement of southwesterly or rain-bearing air currents into quite high latitudes.

In contrast to this pressure arrangement is that for the preceding October, when the oceanic high-pressure system lay far to the west, thus permitting easy access in lower latitudes of winds from the southwest or rainy quarter. The effect of the ingress of air from this quarter was so marked that it can not be appreciated by the mere statement that the ensuing rainfall exceeded the normal over a large area. The excess was so extraordinary that in Washington comparative data showed the month to be the wettest October since state-wide records had been kept, a period of 35 years. In Oregon it was the wettest October for the State as a whole since 1900, and for the western division the wettest since 1890. In California the state-wide average for this October had not been equaled since 1899, while for certain localities along the north coast the amounts exceeded any October rainfalls of record.

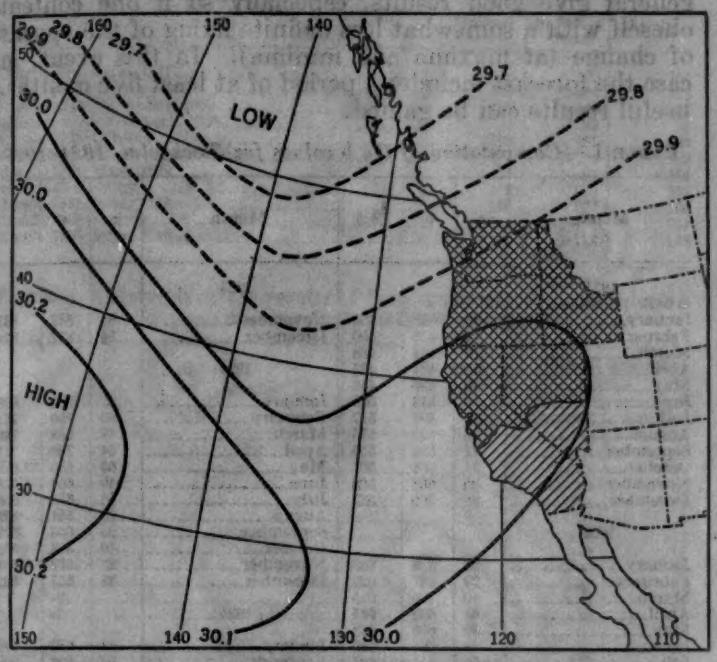

FIG. 3.—October, 1924. Mean 8 a. m. pressure, 7 a. m. at sea, 75th meridian time. A notably wet month over much of the Pacific forecast district. Region of *subnormal* precipitation shown by hatched lines, *supernormal* by cross-hatched lines

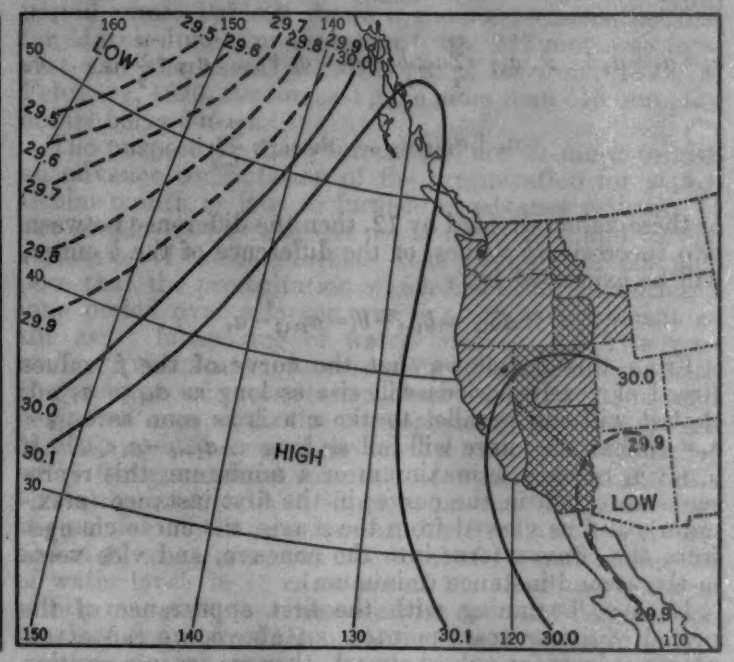

FIG. 4.—October, 1925. Mean 8 a. m. pressure, 7 a. m. at sea, 75th meridian time. A dry month over much of the Pacific forecast district. Region of *subnormal* precipitation shown by hatched lines, *supernormal* by cross-hatched lines

NOTES TO FIGURES 1 AND 2

[1] Total amount, all directions, 0.25 inch.
[2] Only one rain in 10 years; amount, 0.01 inch.
[3] Total, 0.09 inch.
[4] Total amount, all directions, 0.08 inch.
[5] 100 per cent east.
[6] 33 per cent northeast, total 0.01 inch; 67 per cent southeast, total 0.02 inch.
[7] Northeast rain not typical; caused by freak storm of September, 1918; 4.56 inches falling while wind was northeast.
[8] Abnormal north and northwest components caused by rainstorm of September, 1918.

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(1) MONTHLY WEATHER REVIEW, vol. 53. Von Herrmann. Rain-Bearing Winds at Atlanta, Ga.
(2) MONTHLY WEATHER REVIEW, Supplement No. 1. Bowie and Weightman. Types of Storms in the United States and Their Average Movements.
(3) Weather Forecasting in the United States, Washington, 1916.

TWELVE YEARS OF LONG-RANGE FORECASTING OF PRECIPITATION AND WATER LEVELS

By AXEL WALLÉN

[Stockholm, Sweden]

(Translation by B. M. Varney from the Köppen-Heft der Annalen der Hydrographie, 1926)

Each year since 1915 I have published, usually in February, an advance computation of the probable tendency of precipitation and water level in Sweden for the ensuing 12 months. In view of the very considerable period during which these long-range forecasts have been made and tested, I wish to give in what follows a short review of the results.

With regard to the methods used I shall speak briefly, since the principles have been set out more in detail elsewhere.[1] They are based on the existence of a period a few years in length, of an average value of some 28 months, and on a period that averages 11 years, which shows also two secondary maxima and minima within this 11 years. This latter period is very important in the case of lakes that have large storage capacity, e. g., Lake Wenner; on the other hand, its significance is relatively less conspicuous in the case of precipitation changes and as regards the levels of waters not characterized by great reservoirs of that sort.

The method I have found most useful in preparing the forecasts here set forth may be described most simply as a study of the variations of the elements involved, the yearly period of each having first been eliminated; after such elimination these elements showed a period most clearly, the average length of which is 28 months, with, however, considerable irregularity.

If we designate the original monthly values as

$$a_1\ a_2\ a_3\ \ldots\ \ldots$$

(smoothed by forming running five-month values), and

[1] Axel Wallén, Vanerns Vattenstandsvariationer. Meddelanden fran Hydrografiska byran. 1. Stockholm, 1910.—Les previsions des niveaux d'eau et des debits en Suede. Geograf. Annaler h. 3. 4. 1919.

then call the 12-month values formed of these (thus eliminating the yearly period)

$$b_1\ b_2\ b_3\ \ldots\ldots$$

thus:

$$b_1 = a_1 + a_2 + \ldots a_{12} = \sum_{1}^{12} a_1;\ b_2 = a_2 + a_3 + \ldots a_{13} = \sum_{2}^{13} a_1;\ \ldots b_k$$

$$= a_k + a_{k+1} + \ldots a_{k+11} = \sum_{1-k}^{1-k+11} a_1$$

or these values divided by 12, then the difference between two successive b values, or the difference of the b curve, will be expressed by

$$\Delta b_{1+1} = b_{1+1} - b_1 = a_{1+12} - a_1$$

From this it follows that the curve of the b values (freed of yearly period) will rise as long as $a_{1+12} - a_1 > 0$; that it will run parallel to the x axis as soon as $a_{1+12} - a_1 = 0$; that the curve will fall as long as $a_{1+12} - a_1 < 0$. If $a_{1+12} - a_1$ reaches a maximum or a minimum, this represents an epoch in the curve; in the first instance (maximum), and as viewed from the x axis, the curve changes from the convex form into the concave, and vice versa in the second instance (minimum).

If now, beginning with the first appearance of the period of a few years pointed out above, we can extrapolate at least for a short stretch, then we are in a position to compute in advance the corresponding monthly values, or at any rate their magnitude in relation to the value for the corresponding months of the previous year. In the space of time for which one has computed a decline of the b curve, the corresponding a value must be lower than that for 12 months previous. If the curve is passing an epoch, then the difference according to absolute values must be at a maximum.

If the b curve reaches its minimum, then the corresponding a values are like those for 12 months previous. If the b curve rises the a values are higher than 12 months previous; at an epoch this difference is greatest; at a maximum of the b curve the corresponding a values are like those 12 months previous, etc. The assumption that this is a usable method rests upon the fact that the period of a few years is so regular that it allows extrapolation to be carried out with some certainty. If one does not carry this entirely too far, but is satisfied to extend it at the most to a year (in other words, if he is content not to use all of a half period), then this method of procedure is allowable.

In Table 1, I have brought together the a and b values for the rainfall at Stockholm from January, 1921, to May, 1926. From them it is to be observed how the b curve oscillates: minima appear in March, 1921, October, 1922, and December, 1924; maxima in March, 1922, and November, 1923; since the beginning of 1925 the curve is rising. According to the average length of the oscillations, there should be expected a new maximum 14 months after December, 1924; that is, in February, 1926. The precipitation up to and including July, 1926, should be larger than for the preceding 12 months, and thereafter during approximately another 14 months again smaller than in the corresponding months of the previous year.

Forecasts arrived at in this manner may not infrequently fail in case one is dealing with a particular month. The values in the table show small discontinuities. It is therefore advisable not to apply the method to a shorter space of time than that of the five-month values. Neither is it possible to fix in advance the exact time of the maxima and minima of the curve; the forecast failures that result from using this curve are serious. But in spite of this, experience has shown that the forecasts in general give good results, especially so if one content oneself with a somewhat less definite fixing of the epochs of change (at maxima and minima). In this event, in case the forecast includes a period of at least five months, useful results can be gained.

TABLE 1.—*Computation of the b values for Stockholm, 1921–1926*

Month	a	b	$\frac{1}{5}\sum_{1}^{5} b$	Month	a	b	$\frac{1}{5}\sum_{1}^{5} b$
1921				1923			
January	68	532	489	November	63	848	832
February	4	476	490	December	54	837	824
March	6	454	488	1924			
April	32	481	484	January	37	834	806
May	10	496	488	February	65	760	781
June	96	512	502	March	58	753	749
July	82	497	517	April	64	720	715
August	45	522	535	May	66	680	668
September	17	556	555	June	49	664	678
October	31	588	567	July	56	675	656
November	36	608	568	August	73	653	639
December	84	560	582	September	95	606	622
1922				October	40	598	598
January	53	528	606	November	23	577	601
February	29	627	622	December	38	555	602
March	40	706	645	1925			
April	64	689	665	January	48	670	599
May	30	676	663	February	43	606	609
June	48	625	646	March	11	583	626
July	51	618	625	April	56	628	623
August	144	621	599	May	45	643	627
September	96	586	589	June	27	652	639
October	14	546	583	July	171	631	642
November	23	574	577	August	11	640	637
December	33	586	579	September	70	646	636
1923				October	84	614	------
January	46	594	591	November	38	651	------
February	32	597	606	December	47	------	------
March	5	603	632	1926			
April	24	662	657	January	27	------	------
May	58	702	681	February	52	------	------
June	60	728	710	March	17	------	------
July	59	714	737	April	24	------	------
August	147	747	765	May	82	------	------
September	102	800	790				
October	73	840	814				

NOTE.—In column b, for example, the number shown opposite 1921, VI (June), is the sum of the known values for the months I–XII, 1921, in column a. In column $\frac{1}{5}\sum_{1}^{5} b$ the number shown opposite 1921, VI, is the mean of the known values for the months IV–VIII, 1921, in column b.

With reference to the single-month values for Stockholm for 1921, an investigation of them, which is too long to describe here, shows that the percentage of hits is not more than 65. If instead of these monthly values we take rainfall sums for the different periods included in the forecasts, we get the result set forth in Table 2. It is evident that the forecasts were successful in ten cases out of eleven. For the sake of comparison, I have also given the normal values of precipitation for the periods concerned.

As an example of the preparation of a forecast on the basis of Table 1, we take the following case from the recent period. In February, 1925, we knew the maximum of the b curve in November, 1923, on the basis of which we could compute, by extrapolation, a minimum for January, 1925. Accordingly, from July, 1925, heavier rainfall than for the preceding 12 months must set in. During the months March to June, 1925, that is, precipitation must be slighter, and that from July, 1925, to February, 1926, heavier, than that which fell during the 12 months preceding. With respect to the values for single months these forecasts were verified except for August and September, 1925, and for January, 1926, as the comparison in Table 3 shows.

TABLE 2.—*Results of the long-range advance computation of precipitation amounts*

Period	Rainfall amounts (mm.)		
	Normal	Forecast	Actual
March, 1921–June, 1921	156	<109	144
July, 1921–February, 1922	413	>364	378
March, 1922–December, 1922	499	>440	543
January, 1923–February, 1923	70	< 82	78
March, 1923–October, 1923	308	<487	528
November, 1923–February, 1924	171	>134	219
March, 1924–May, 1924	111	> 87	188
June, 1924–February, 1925	458	<660	485
March, 1925–June, 1925	156	<237	139
July, 1925–February, 1926	413	>416	501
March, 1926–May, 1926	111	>112	123

TABLE 3.—*Example of the results of long-range advance computation of precipitation for individual months*

Month	Rainfall amounts (mm.)	
	Forecast	Actual
1925		
March	<58	11
April	<64	56
May	<66	45
June	<49	27
July	>56	171
August	>73	11
September	>95	70
October	>40	85
November	>23	38
December	>38	47
1926		
January	>48	27
February	>43	52

In this case, also, the epoch falls in summer, and for it the forecast proves untrustworthy. The high July value is somewhat misleading, too, since the heavy precipitation is made up of heavy local showers. As for the period sums, Table 2 shows a good agreement, because for March–June a preciptation below 237 mm. was forecast and the actual was 139 mm.; for July, 1925, to February, 1926, the forecast gave more than 416 mm., the actual being 501 mm.

The purpose of these forecasts is not so much to give an advance computation of the precipitation for a particular month as it is to furnish an advance estimate of our lake levels for practical use in navigation and for the regulation of the lake levels. It is precisely for this purpose that the precipitation which has occurred during a long period over a larger area is quite as significant as the exact forecasting of water levels. . . . The generalized precipitation forecasts since 1915 compared with the amounts of precipitation observed in Svealand, and compared also with the corresponding previous year's rainfalls as well as with the normal values, . . . [together with] the generalized forecasts of water levels and the levels observed in Lake Siljan in Salarna [2] . . . show that the rainfall tendencies forecast for Svealand were verified in 13 to 14 cases out of a total of 15, and tendencies of water levels in 15 cases out of 16. Such percentages of hits may well convince one who does not demand too much of the method that it has a practical value.

[2] The author presents two tables embodying all these forecasts and their verifications.—*B. M. V.*

BLUE-SKY MEASUREMENTS

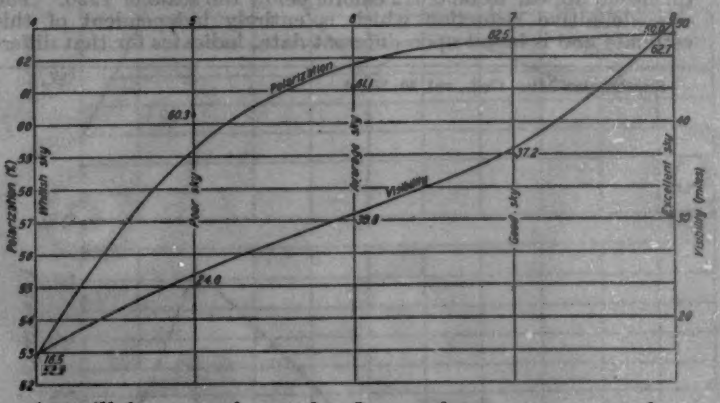
By IRVING F. HAND

[Weather Bureau, Washington, June 30, 1927]

During the latter part of 1925 Dr. F. Linke, of the Universitats-Institut fur Meteorologie und Geophysik, Frankfort on the Main, Germany, sent a series of color-match cards to 17 first-class meteorological services, one being the United States Weather Bureau. Commencing with January, 1926, the blueness of the sky has been noted at the Solar Observatory, American University, District of Columbia, on days when both solar radiation and skylight polarization measurements have been made. Linke states in his letter that the first measurements of the blueness of the sky of which we have record were made by H. B. de Saussure in Europe 150 years ago, and just a hundred years later the work was taken up by H. Wild. Although measurements of this kind have been made more or less frequently in Europe since the resumption of this research by Wild, but few have been made in this country.

The color-match charts consist of a series of 14 cards of graded hues ranging from almost white to a very dark blue, care having been taken to insure permanency of color and trueness of shade. The observation consists in selecting a card which when held against the blue sky 90° from the sun and in its vertical will most nearly match the color of the sky, which at this point is, generally speaking, the darkest. It is also the point of maximum polarization of skylight.

At Washington all the observations made to date cover the range of only the five cards numbered 4 to 8, inclusive. Skies whiter than that represented by card No. 4 are unfit for solar radiation measurements at normal incidence, while skies darker than No. 8 have not been observed at this station. We may therefore, for the sake of convenience, arbitrarily designate the cards as follows: No. 4, whitish sky; No. 5, poor sky; No. 6, average sky; No. 7, good sky; and No. 8, excellant sky.



As will be seen from the figure there appears to be a very close relation between the blueness of the sky and horizontal visibility. This is to be expected as water vapor and dust both whiten the sky and decrease visibility.

The relation between sky color and the elements, visibility, polarization, solar radition intensity at 2 air mass (zenith distance of the sun 60°), dust particles per cubic centimeter, relative humidity, vapor pressure, and

the average number of days since rain occurred is presented in Table 1.

Very slight correlation exists between sky color and the number of dust particles per cubic centimeter. This is probably explained by the fact that at Washington the dust particles consist principally of smoke of local origin, which does not extend to any considerable height.

The intensity of solar radiation increases with increase of depth of color of the sky, but the most rapid increase occurs with change in sky color from white to poor sky, and a small increase with change from poor to average sky. The increase from this point on is quite regular. It is thought that a longer series of measurements, which would tend to eleiminate seasonal effects, would smooth out this apparent anomaly.

Generally speaking, there seems to be a fairly close relation between sky color and both relative humidity and vapor pressure. Unquestionably a longer series of measurements would intensify this relation. Unfortunately, however, the paucity of observations does not permit of dividing them into seasonal groups.

One of the most interesting facts brought to light by the table is the very close relation between sky color and the number of days since rain occurred. The reason is apparent however, when we consider the efficiency of precipitation as a cleanser of the atmosphere.[1]

Rapid indications of the vertical distribution of precipitable water and dust in the atmosphere might be made by matching the color of the sky against these cards during airplane flights. Unquestionably, at an altitude of 15,000 feet skies as dark, as that represented by card No. 12 would be observed, and probably even darker.

TABLE 1.—*Relation between sky-color and other meteorological elements*

Color scale	Visibility	Skylight polarization	Solar radiation at normal incidence, 2 air mass. Gr. cal. cm.^{2}	Number of dust particles per cubic centimeter	R. H.	V. P.	Average number days since rain
	Miles	*Per cent*			*Per cent*	*Inch*	
4	16.5	52.9	1.02	883	52	0.228	2.5
5	24.8	60.3	1.18	594	53	.202	2.0
6	30.8	61.1	1.19	660	49	.126	1.8
7	37.2	62.5	1.26	528	44	.172	1.1
8	50.0	62.7	1.37	627	33	.031	0.0

[1] Kimball, Herbert H. & Hand, Irving F. 1924. Investigation of the dust content of the atmosphere. Mo. Wea. Rev. 52:133-141. Washington.

NEW DEFINITIVE SCALE FOR SOLAR-CONSTANT VALUES

The following letter explains a recent change made in the scale of solar-constant values published on the Washington Daily Weather Map:

SMITHSONIAN INSTITUTION,
Washington, D. C., June 27, 1927.

DEAR PROFESSOR MARVIN: A few days ago we mailed to the observers in Chile an entirely new set of tables of reduction of the short-method and long-method observations which are based on an exhaustive study of four years of the latest and best observations.

As the values hereafter are intended to be definitive, I have directed the inclusion of a horizontal factor to be applied to all values to reduce them to the scale of 1920, which is also, so far as we know, the scale of the Mount Wilson observations. You will recall that in my recent paper entitled "A Group of Solar Changes"[1] I indicated in Table 2 that the values as now being furnished appear to be 0.012 calorie below the scale of 1920. The new definitive reduction which is entirely independent of this estimate and is based upon different data, indicates for that difference approximately 0.014 calorie; that is to say, the difference between the earlier estimate and this final reduction is within one-tenth of 1 per cent of the value of the solar constant.

We have compared a large number of results based upon the new method of reduction with the results which have been daily furnished you for the last 16 months, and we find that the average accidental difference of daily values (the definitive new method as compared with the provisional method) comes out 0.004 calories, or two-tenths of 1 per cent.

You will be glad to know that the definitive reduction has been based on Montezuma data alone, just as if no other station in the world existed, and that the residual corrections for imperfections of the function-transmission curves and for uncertainty of allowances for atmospheric humidity—those final residual corrections, I say—are always less than 1 per cent and for about 75 per cent of the days are less than one-tenth of 1 per cent. If they were omitted altogether, the result would be negligible in monthly means.

When the telegrams begin to arrive on the new definitive scale, there will be a sudden jump of approximately 0.014 calorie on account of the reduction to the scale of 1920. Thereafter I anticipate there will be no further change.

Very truly yours,

C. G. ABBOT, *Acting Secretary.*

[1] Smithsonian Misc. Coll., vol. 80, No. 2.

NOTES AND ABSTRACTS

THE CLIMATE OF COIMBRA[1]

By Prof. ANSELMO FERRAZ DE CARVALHO

Professor Carvalho has summarized the meteorological observations made at the Observatory of Coimbra during the 55 years 1866–1920 and presents his results in two parts. The first treats of the elements of climate of Coimbra as defined by the entire observational period; the second treats of the temperature of the air in very great detail, and the statistics (the tables of data) give the daily means, the daily maxima and minima for the 50-year period, 1867–1916. Daily means in groups of 5 days each are also presented.

Coimbra, N. latitude 40° 12′, W. longitude 8° 25′, altitude 141 meters, occupies a central position in the western margin of the Iberian Peninsula, and its climate therefore represents a form intermediate between that of the northern and the southern portions of this peninsula. The latter is very much under the influence of the semi-permanent area of high pressure centered over the Azores, and we should therefore expect rather strong climatic variations, notwithstanding its marine exposure on the west.

The series of temperature observations is quite homogeneous throughout the entire period and the means have been calculated from the 24-hour readings.

The averages of the annual means in groups of 20, 30, 40, 50, and 55 years are as follows:

	°C
1866–1885	14.82
1866–1895	14.70
1866–1905	14.72
1866–1915	14.68
1866–1920	14.66

Thus showing first a slight rise and the in the last half of the record slowly diminishing temperature. The annual mean may be taken as 14.7° C.; the lowest yearly mean was in 1889 with 13.56° and the second lowest annual mean was 13.74° in 1917; the highest annual means were in 1881 and 1899 with 15.85° and 16.20°, respectively; hence the coldest years were but about 1° C. below the mean and the warmest years 1.5° above the annual mean, or an amplitude of 2.5° C. (4.5° F.).

Discussing sun spots and air temperatures, Professor Carvalho observes that the generally recognized relation of sun spots to terrestrial temperature—maximum spottedness of the sun corresponding to low temperature and the opposite—is not confirmed by the Coimbra observations. He states (p. 42):

> With exception of the maximum of 1883.9, 1894.1, and 1917.8 which correspond to minimum temperatures, the variations in the number of spots are better represented by a curve parallel to and and not opposite to that of the variations of temperature * * *.

The record of precipitation shows two groups of maximum rains and one of minimum, which, considering Coimbra's maritime exposure, is in opposition to Brückner's rules. The years of heavy precipitation were 1879–1881 and 1914–1916; the years of deficient rains were 1896–1898. The last-named series of dry years was preceded by the year of greatest precipitation in the entire series. Here again the tendency of one extreme being immediately followed by another in the opposite direction is manifest.

Students of weather periodicities will find valuable material in Professor Carvalho's work.—*A. J. H.*

[1]The Climate of Coimbra, Anselmo Ferraz de Carvalho, Lisbon, 1922.

THE RANGE OF ATMOSPHERICS

[Reprinted from Nature, May 7, 1927]

The distances over which an atmospheric may produce disturbance of broadcast reception was discussed. The committee organized experiments in which observers in the British Isles, Norway, Germany, France, Spain, Morocco, and Madeira recorded disturbance of broadcast talks, while the sources of the atmospherics were identified by radio position finding by the organization set up in the Department of Scientific and Industrial Research on the advice of its Radio Research Board. Many of the sources were found to lie in regions of meteorological disturbance. Atmospherics from beyond the Azores have disturbed the reception of Daventry's signals in Paris and of London's signals in Aberdeen, and a thunderstorm at Rome disturbed reception in Spain, France, Madeira, the British Isles, and Norway. Many atmospherics are heard at distances exceeding 1,800 miles from their sources, and may reach at least 4,500 miles. There is no evidence of the presence of many atmospherics with a short range of disturbing effect.—*R. A. Watson Watt*, at meeting Royal Meteorological Society March 20, 1927.

PRELIMINARY OBSERVATIONS ON SOLAR ACTIVITY AND RADIO RECEPTION

[Laboratory for Special Radio Transmission Research, conducted jointly by the Bureau of Standards and the American Section of the International Union of Scientific Radio Telegraphy]

Recently a study of our observational data has been begun in regard to a possible relationship between radio

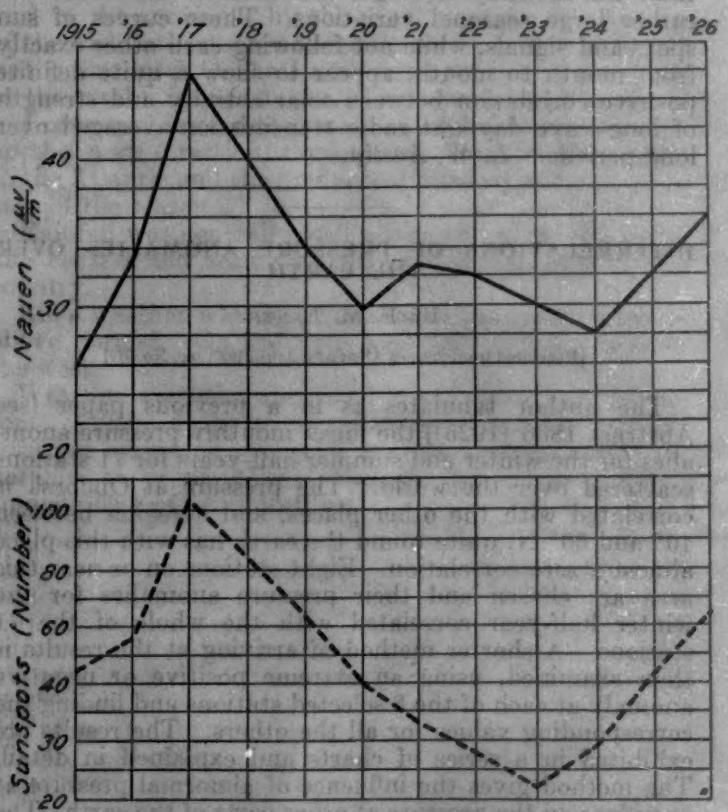


FIG. 1.—Annual average signal intensity of Nauen (AGS) and sun-spot numbers

signal strength and solar activity. For this purpose we have rough shunted telephone observations on Nauen as

received in Washington, beginning in 1915, and more accurate measurements since 1922. Some preliminary results are shown in the figures.

In Figure 1 the annual averages of sun-spot numbers and of daylight signal strength of Nauen, reduced to a constant antenna current, from 1915 to 1926, are given. The earlier years of the Nauen reception curve have little claim to accuracy, but it is certain that there was a reception maximum in 1917 and low values from 1920 to 1924.

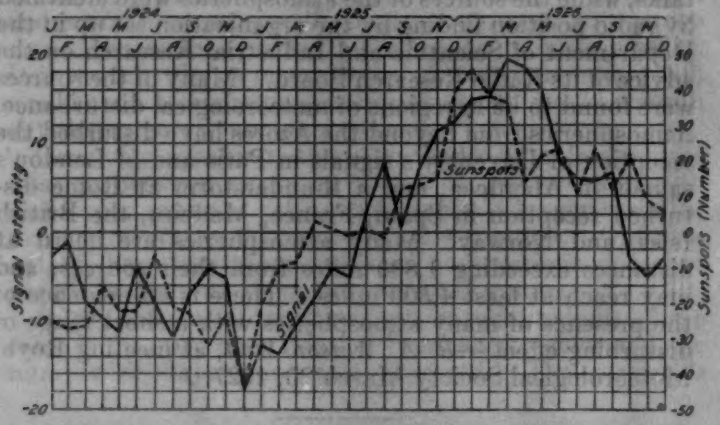


FIG. 2.—Monthly deviation from three-year monthly averages of sun-spot numbers and signal (LY, KET, AGS, FU, FT, 10 a. m. and 3 p. m.)

Figure 2 shows the relationship between the monthly average sun-spot numbers and the deviations of the individual monthly daylight means of several stations from the averages of the corresponding months for the three years—1924, 1925, and 1926. The deviations rather than the monthly averages are used to eliminate the rather large seasonal variations. These curves of sun spots and signals, while not following each other exactly from month to month, appear to show a quite definite positive correlation between solar activity and strength of long-wave daylight radio transmission averaged over long periods.—*L. W. Austin.*

INTERRELATIONS OF PRESSURE ANOMALIES OVER THE EARTH[1]

By F. M. EXNER

[Reprinted from Science Abstracts, April, 1927, sec. No. 917]

The author tabulates as in a previous paper [see Abstract 1836 (1925)] the mean monthly pressure anomalies for the winter and summer half-years for 71 stations scattered over the world. The pressure at Obdorsk is correlated with the other places, and a region between 40° and 60° N. quite round the earth has with this place almost a zero correlation. Eight stations on or near this area are chosen and their pressure anomalies for the winter half-year correlated with the whole of the 71 stations. A shorter method of arriving at the results is then examined, using an extreme positive or negative anomaly at each of the 8 selected stations and finding the corresponding values for all the others. The results are exhibited in a series of charts and explained in detail. The method gives the influence of abnormal pressure at one place on the pressure at other parts of the earth. The possible dynamical and thermal considerations which may produce these results are examined and applied in several cases. Polar regions are mostly places of maximum influence, while southwards over the sea there are also places of large correlation. Continental regions have a small influence. Next, assuming particular anomalies at 2 selected stations, the author considers how the average pressure distribution is produced, and gives tables and graphs of his tests for six combinations of two places in the Northern Hemisphere when their pressure anomalies are of the same sign and of opposite sign, using again the winter half-year. For a clearer picture of the origin of the pressure distribution over the earth a longer series of observations than 30 years would be necessary, and combinations of pressure anomalies at three places should then be taken, with also due consideration to the temperature anomalies.—*R. S. R.*

[1] Akad. Wiss. Wien. Ber. 135. 2a. No. 7-8, pp. 333, 355, 1926.

WEATHER BUREAU STAFF MEETINGS, 1926-27

By EDGAR W. WOOLARD, Secretary

The regular biweekly meetings of the scientific and technical staff of the Central Office of the United States Weather Bureau, initiated in the autumn of 1923, have been continued on the same plan as heretofore during the winter of 1926–27. Following is a list of the discussions. (Asterisks denote speakers not officially connected with the Weather Bureau.) Meetings during previous seasons have been reported in the MONTHLY WEATHER REVIEW, 1924, 52, 35–36, 166; 1925, 53, 264; 1926, 54, 215–216.

October 6, 1926

E. W. Woolard. Seiches in lakes, and the application of Chrystal's theory to Lake Vetter.

**C. G. Rossby.* Remarks on the influence of winds on lake levels.

October 20, 1926

W. R. Gregg and *L. T. Samuels.* National and international sounding balloon explorations; preliminary results of the sounding balloon observations made at Royal Center, Ind., during May, 1926.

November 3, 1926

**L. Gorczynski.* Demonstration of thermoelectric radiation instruments, and some solar radiation measurements obtained in the Sahara Desert.

November 17, 1926

H. H. Kimball. A review of Ångström's paper on "Radiation and Climate."

December 1, 1926

E. W. Woolard. The thermodynamical relations of the free atmosphere.

L. T. Samuels. The graphical reduction and representation of aerological data at the Lindenberg Observatory.

W. R. Stevens. The tephigram.

December 15, 1926

W. J. Humphreys. The tornado.

January 12, 1927

W. C. Haines. The Byrd Arctic expedition.

S. P. Fergusson. The University of Michigan expedition to Greenland.

January 26, 1927

R. H. Weightman. The application of the polar front theory to American weather maps.

February 9, 1927

E. W. Woolard. Modern meteorology.

February 23, 1927

**C. G. Rossby.* Atmospheric turbulence: some recent results and their practical applicability.

March 9, 1927

W. R. Stevens. The equatorial front.

March 23, 1927

**J. E. Ives.* Studies of daylight.

April 6, 1927

**E. Sydenstricker.* Weather and respiratory diseases.

April 20, 1927

**M. B. Waite.* Relation of weather to plant diseases.

May 4, 1927

E. B. Calvert. Proposed changes in the system of collecting and distributing observations.

May 18, 1927

**T. B. Rice.* Relations of climate and weather to soils.

WEATHER IN THE AMERICAS AS AFFECTING TRADE

[Cable reviews to Commerce Reports]

British Guiana, May 24.—The heavy seasonal rains will have a beneficial effect on coming crops, and help to maintain transportation on the rivers, which is the primary means of communication with the interior mining regions.

Uruguay—Montevideo, May 25.—The drought which prevailed in the interior was relieved by recent rains, but reports fail to indicate that the precipitation was general.

Trinidad, May 26.—Heavy rains in April proved favorable to the cacao crop but retarded sugar production.

METEOROLOGICAL SUMMARY FOR SOUTHERN SOUTH AMERICA, APRIL, 1927

By J. BUSTOS NAVARRETE, Director

[Observatorio del Salto, Santiago, Chile]

The region of Chile receiving rain during April extended from Concepcion to Magellanes.

The most important anticyclonic centers were the following: That of the 1st–3d bringing generally fair weather and moderate temperatures; that of the 13th–19th forming in the region of Chiloe and immediately moving toward the Atlantic coast and northern Argentina accompanied in Chile by fine, dry weather with severe cold −21° F. (−6° C.) at Lonquimay; and that of the 19th–25th remaining stationary in the region of Llanquihue and Chiloe and giving rise to fair weather and cold wave conditions.

There were four important cyclonic depressions. From the 4th to the 6th a storm crossed the extreme south, bringing strong winds and rain over the entire region south of Concepcion; the maximum rainfall in 24 hours was 1.38 inches (35 mm.) at Valldívia. The depression of the 12th caused light rain in Chiloe. The depression of the 18th–19th was accompanied by rain as far north as Valdivia, where the amount was 0.75 inch (19 mm.) and that of the 28th–30th brought strong north winds and rain still farther north to Concepcion, the maximum 24-hour amount at this time being 1.85 inches (47 mm.) at Puerto Montt.

The paths of these depressions lay between latitudes 45° and 55° south, crossing the southern part of the continent.—*Transl. W. W. R.*

METEOROLOGICAL SUMMARY FOR BRAZIL, APRIL, 1927

By J. DE SAMPAIO FERRAZ, Director

[The Meteorological Office, Rio de Janeiro]

Secondary circulation was still more active than in the previous month. Six anticyclones crossed the southern part of the continent by the usual tracks. Depressions of the high latitudes were remarkably frequent, especially in the first week. The fourth HIGH brought fresh winds to the coast. The fifth area of high pressure, after a stop of a couple of days in the extreme south, followed an east-northeastern direction, causing high winds in its passage to the Atlantic and the first accentuated drop of temperature of the season.

Rainfall was generally well above normal in the north and central and scarce in the southern section of the country.

Rio's weather was dry, fine, and warm, with pressure above normal. On the 24th were felt high winds from the west.

Weather, excepting restricted local cases of adversities, some of them owing to irregular distribution of rainfall, either in excess or otherwise, was in a general way favorable to crops. Vegetables in the south suffered through lack of precipitations.

BIBLIOGRAPHY

C. FITZHUGH TALMAN, Meteorologist in Charge of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

American geophysical union. Section of terrestrial magnetism and electricity.
Reports presented at annual meeting, April 18, 1921. Washington. 1922. p. 54–77. figs. 25 cm. (Repr.: Bull. nat. research council, no. 17.)

Berlage, H. P., *jr.*
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SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING MAY, 1927

By HERBERT H. KIMBALL, Solar Radiation Investigations

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1924, **52**: 42, January, 1925, **53**: 29, and July, 1925, **53**: 318.

From Table 1 it is seen that solar-radiation intensities averaged above the May normals at all three stations. At Washington a noon intensity of 1.45 gram-calories per minute per square centimeter obtained on the 27th equals the highest noon intensity heretofore obtained at that station in May.

Table 2 shows a deficiency in the total solar radiation received on a horizontal surface from the sun and sky at all three stations for which normals have been determined. The deficiency is pronounced at Washington and Madison and is due to unusually cloudy conditions.

Skylight-polarization measurements were mad at Washington on only one day, May 27, and the percentage was 56, which is only slightly above the mean for May at that station. At Madison measurements obtained on five days give a mean of 57 per cent with a maximum of 64 per cent on the 12th. These are only slightly below the corresponding averages for May at Madison.

TABLE 1.—*Solar radiation intensities during May, 1927*

[Gram-calories per minute per squre centimeter of normal surface]

Washington, D. C.

Date	Sun's zenith distance										
	8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
May 2	6.50	0.62	0.74	0.92	1.07	1.18					5.36
May 5	11.38					1.27					10.21
May 11	13.61					1.26					9.83
May 20	10.97					1.34	1.10				9.83
May 27	6.27	0.68	0.82	0.98	1.20	1.45					5.79
Means		(0.65)	(0.78)	(0.95)	(1.14)	1.30	(1.10)				
Departures		+0.02	+0.07	+0.13	+0.15	+0.02	+0.11				
Madison, Wis.											
May 5	6.02				1.20						5.16
May 12	4.95				1.26	1.45					4.57
May 16	4.17				1.20	1.45					3.15
May 17	6.02					1.25					10.97
May 18	5.36					1.39					6.76
May 21	12.68					1.31					14.60
May 25	7.04				1.14						7.87
May 26	8.18					1.45					6.76
Means					1.20	1.38					
Departures					+0.09	+0.02					
Lincoln, Nebr.											
May 11	4.57		1.00	1.13	1.30	1.54	1.21	1.02	0.90		3.81
May 13	8.48				1.25						7.29
May 14	6.02			1.08	1.26	1.50					4.37
May 23	13.61						1.05	0.92			12.68
May 25	9.83		0.86	1.02	1.22	1.44					6.50
May 26	8.18		0.84	1.02	1.20	1.44					8.48
May 30	7.57					1.29	1.05	0.85	0.71	0.60	8.81
Means			0.90	1.06	1.25	1.40	(1.13)	0.97	0.84	(0.60)	
Departures			+0.09	+0.11	+0.11	+0.01	+0.03	+0.04	+0.03	−0.12	

[1] Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation						Average daily departure from normal		
	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Washington	Madison	Lincoln
1927									
Apr. 30	417	473	484	333	304	[1] 616	−33	−23	−7
May 7	346	338	415	261	307	515	−106	−122	−51
May 14	375	430	551	261	343	634	−92	−47	+27
May 21	443	366	592	343	296	[2]	−43	−112	+31
May 28	370	298	438	366	527	[2]	−122	−181	−76
Deficiency since first of year on June 3							−7,602	−6,048	−6,000

[1] Five-day mean. [2] Main-spring of register clock broken.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. Edwin T. Pollock, Superintendent U. S. Naval Observatory]

[Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson observatories]

Date	Eastern standard civil time	Heliographic		Area [1]	
		Longitude	Latitude	Spot	Group
1927	*h. m.*	°	°		
Apr. 1 (Harvard)	13 36	−67.0	+14.0		409
		−35.0	+19.0	106	
		+32.0	−23.0		91
Apr. 2 (Harvard)	12 49	−73.0	+14.0		273
		−56.0	+15.0		500
		−51.0	−23.0	91	
		−21.0	+11.0	91	
		−21.0	−12.0		91
		+53.0	+11.0		212
Apr. 8 (Harvard)	9 52	−64.0	+14.0	182	
		−58.0	−16.0		121
		−52.0	−15.0		424
		−40.0	−13.0		288
		+24.0	+14.0		333
Apr. 9 (Harvard)	9 51	−51.0	+15.0		136
		−44.0	−15.0		106
		−37.0	−15.0		379
		−26.0	−12.0		318
		+37.0	+14.0		304
Apr. 13 (Harvard)	10 51	−2.0	−21.0		76
		+11.0	−16.0		304
		+26.0	−12.0		61
Apr. 25 (Harvard)	9 40	−78.0	+4.0	288	
		−31.0	−17.0		288
		−8.0	−21.0	76	
		+28.0	+24.0		106
Apr. 29 (Harvard)	16 49	−53.0	−22.0		106
		−19.0	+4.0	45	
		+26.0	−14.0		242
Apr. 30 (Harvard)	12 5	−16.0	−20.0		152
		−9.0	+4.0		136
		+36.0	−12.0	61	
May 1 (Naval Observatory)	11 48	−5.0	−19.5		108
		+6.5	+4.5		108
		+50.0	−14.0		31
May 2 (Naval Observatory)	11 45	−74.0	+10.0	123	
		+9.5	−19.5		216
		+19.5	+4.5		93
		+62.5	−13.5		46
May 3 (Naval Observatory)	11 48	−60.0	+10.0	77	
		−54.0	−16.0		62
		+22.5	−19.5		247
		+33.0	+4.5	46	
May 4 (Harvard)	9 24	−53.0	−3.0		50
		−48.0	+9.0	81	
		−41.0	−16.0		294
		−6.0	+22.0	49	
		+34.0	−19.0		484
		+43.0	+6.0		63
May 5 (Naval Observatory)	11 44	−38.5	−8.0		139
		−26.0	−16.5		201
		+26.0	+22.0		62
		+44.5	−23.0	19	
		+53.0	−18.0		267
May 6 (Harvard)	9 2	−28.0	−6.0		95
		−23.0	−10.0	83	
		−15.0	−16.0		388
		+35.0	+24.0	63	
		+66.0	−19.0		115
May 7 (Naval Observatory)	12 25	−10.0	−7.5		108
		+3.0	−14.5		216
		+14.0	+19.0		77
		+50.5	+23.5	15	
		+84.0	−18.0		247

[1] Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere.

Date	Eastern standard civil time	Heliographic		Area	
		Longitude	Latitude	Spot	Group
1927	h. m.	°	°		
May 8 (Harvard)	12 34	−1.0	−4.0	30	
		+6.0	−8.0	69	
		+15.0	−14.0		239
		+29.0	+18.0		47
May 9 (Naval Observatory)	12 32	−70.0	−11.5		154
		−59.0	−9.5		15
		−39.5	+19.0	15	
		+14.5	−5.0	25	
		+22.0	−8.0	46	
		+27.0	−19.5		46
		+28.0	−14.0		170
		+45.0	+17.5		31
		+52.0	−7.5		31
		+62.0	−25.0		154
May 10 (Naval Observatory)	12 33	−67.0	+20.0	93	
		−57.0	−11.5		185
		−27.0	+19.5		108
		−15.0	+18.5		154
		+37.0	−7.0	62	
		+41.0	−19.5		62
		+47.5	−14.5		139
		+58.0	+18.0		46
		+75.0	−25.0		154
May 11 (Naval Observatory)	12 11	−82.0	−10.5	247	
		−57.0	+20.0		77
		−43.5	−12.0		139
		−40.0	−9.5	9	
		−12.5	+19.0		123
		−1.0	+18.5		340
		+27.0	+22.0		31
		+50.5	−7.5		62
		+60.0	−14.5		108
		+71.0	+17.5	31	
May 12 (Mount Wilson)	13 10	−69.0	−10.0	171	
		−43.0	+20.0		10
		−30.5	−11.5		124
		−16.0	−10.0	4	
		+4.0	+18.0		53
		+5.5	−23.0		7
		+16.0	+17.5		911
		+43.0	+29.0		5
		+65.0	−8.0		25
		+75.0	−16.0		23
May 13 (Naval Observatory)	11 46	−55.0	−10.5		185
		−19.0	−11.0		154
		+11.0	+20.0		77
		+24.0	+17.5		741
May 14 (Harvard)	12 0	−42.0	−11.0	163	
		−5.0	−10.0	38	
		+36.0	+18.0		1104
May 15 (Naval Observatory)	11 56	−74.0	−14.0		170
		−29.0	−10.5	108	
		+9.5	−10.5	25	
		+38.5	+19.0		19
		+52.0	+17.5		957
		+68.0	+15.0		46
May 16 (Mount Wilson)	13 0	−74.0	−8.5	6	
		−60.0	−22.0		5
		−59.5	−13.0		110
		−40.5	−25.0		5
		−15.0	−10.0		120
		+23.5	−12.0		14
		+53.0	+18.5		34
		+67.0	+17.0		1550
		+82.0	+14.5		21
May 17 (Naval Observatory)	12 45	−60.0	−8.0		46
		−47.5	+22.0		31
		−45.5	−13.0		77
		−27.0	−24.0		31
		−1.5	−9.5		62
		+63.0	+20.5		62
		+79.0	+17.5		1019
May 18 (Harvard)	17 33	−49.0	−9.0		185
		−27.0	−13.0		137
		−12.0	−22.0	41	
		+30.0	+22.0		88
May 19 (Naval Observatory)	12 1	−60.0	+4.0		62
		−34.5	−8.0		123
		−19.0	−12.5		62
		−17.5	+21.0	9	
		+0.5	−24.0		123
		+42.0	+20.5		93
		+66.0	+27.0	15	
May 20 (Naval Observatory)	11 48	−47.5	+4.0	62	
		−19.5	−8.0		154
		−6.5	−12.5		62
		−4.0	+20.5	15	
		+13.0	−23.5		139
		+55.0	+20.0		185
May 21 (Naval Observatory)	13 33	−72.5	−10.0		93
		−53.0	−12.0		31
		−34.0	+4.0	666 25	
		−4.5	−8.0		170
		+9.5	−13.0	31	
		+27.5	−23.0		77
		+74.0	+20.0	62	
May 22 (Naval Observatory)	11 46	−78.0	+17.5	154	
		−60.0	−9.5	123	
		−41.0	−12.0		31
		−22.0	+4.0	15	
		+8.0	−7.5		185
		+21.5	−13.0	40	
		+40.0	−23.0		31
		+56.0	−27.0		31
May 23 (Naval Observatory)	13 41	−62.0	+17.0	31	
		−48.0	−9.5		93
		−35.0	−27.0		31
		−7.5	+4.0	15	
		+24.0	−8.0		154
		+35.5	−13.0	25	
		+53.5	−23.0	31	
		+69.5	−27.0		93
May 24 (Naval Observatory)	11 47	−53.0	+16.5		62
		−47.5	−25.0		62
		−37.5	−10.0		123
		−22.0	−27.0	25	
		+6.0	+3.5	6	
		+36.0	−8.0		154
		+48.0	−13.0	15	
		+49.5	−4.5		31
		+78.0	−27.0		216
May 25 (Mount Wilson)	14 25	−76.0	−20.0	200	
		−59.0	−20.0		93
		−38.0	+17.0		18
		−33.0	−24.0		34
		−19.0	−10.0		130
		−7.0	−26.0	1	
		+6.0	−9.5		27
		+54.0	−9.0		126
		+65.0	−13.0	8	
May 26 (Naval Observatory)	11 58	−63.5	−20.0	154	
		−45.5	−20.5		185
		−26.0	+17.0		15
		−15.0	−25.0		108
		−7.0	−10.5	77	
		+17.0	−9.5		139
		+64.0	−9.0		154
May 27 (Naval Observatory)	11 49	−49.0	−20.0	185	
		−32.0	−20.0		123
		−13.0	+17.0		9
		−7.0	−25.0		31
		+7.5	−10.5	93	
		+31.0	−9.5		108
		+85.0	−9.5	154	
May 28 (Naval Observatory)	11 46	−37.0	−19.5	185	
		−16.0	−19.0		108
		+11.0	−10.5	62	
		+44.0	−9.5		93
May 29 (Mount Wilson)	12 35	−22.0	−19.0		200
		−0.5	−19.0		159
		+9.5	−20.0		2
		+35.0	−11.0	44	
		+58.0	−9.5		19
May 30 (Naval Observatory)	12 33	−9.5	−19.5	185	
		+13.5	−19.0		123
		+49.0	−11.0	46	
May 31 (Mount Wilson)	14 10	+6.0	−19.5		192
		+29.0	−19.0		97
		+64.0	−12.5	10	

AEROLOGICAL OBSERVATIONS

By L. T. SAMUELS

Free-air temperatures were abnormally high over the southern part of the country and abnormally low over the northern part. (See Table 1.) The pronounced degree to which this latitudinal temperature gradient obtained during the month is well shown by the difference between the mean temperatures for Ellendale and Groesbeck at the 3,500-meter level. This amounted to 16.5° C., whereas the normal difference between these two stations at this height in only 6.2° C. Note also that the difference 16.5° at 3,500 meters is 2.8° *greater* than the difference occurring between the surface at these two stations.

The positive monthly temperature departures for Groesbeck were exceptionally large, amounting to 5.5° C. at 3,500 meters. One of the effects of this abnormally warm air at the upper levels was a decided lack of precipitation throughout the month at this station, measurable amounts falling on only 3 days. At Ellendale, where the upper layers were colder than normal, there occurred an excess in the monthly precipitation, measurable amounts falling on 17 days and the total rainfall exceeded all previous amounts for May for at least 10 years.

The resultant winds at Ellendale, as might be expected in view of the abnormally low temperatures, contained a marked northerly component as compared with the normal southerly component. (See Table 2.) At Groesbeck, however, where temperatures were above normal, the resultant winds contained a greater southerly component than normally.

With but few minor exceptions the relative humidity departures for the month were of opposite sign to those for temperature. The largest departures occurred in the higher levels at Groesbeck, where also the greatest excess in temperature was found. In most cases the vapor pressures were of the same sign as those for temperature.

During the last five days of the month record temperatures prevailed at various levels at Broken Arrow, Groesbeck, and Royal Center. Normal values were exceeded by as much as 14° C. at the 1,500-meter level at Broken Arrow on the 28th. These high temperatures were associated with a pronounced low-pressure area, and as would be expected in view of the small lapse rates and low relative humidities, precipitation during this period was extremely scant.

The free-air winds as shown by pilot-balloon observations at Los Angeles on the 13th and 24th were of special significance in view of the fact that on the following days, viz, 14th and 25th, the surface temperatures at this station were exceptionally high, being 36.7° C. (98° F.) and 33.3° C. (92° F.), respectively. On both occasions this station was on the southwestern boundary of an extensive high-pressure area which covered the cou try west of the Rocky Mountains. The distinctive feature shown by the balloon observations was the existence of unusually deep southeasterly winds of low velocity. These reached 4,300 and 5,500 meters, respectively, on the dates mentioned.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during May, 1927*

TEMPERATURE (° C.)

Altitude (m.) m. s. l.	Broken Arrow, Okla. (233m.) Mean	Broken Arrow, Okla. (233m.) Departure from 9-yr. mean	Due West, S. C. (217m.) Mean	Due West, S. C. (217m.) Departure from 7-yr. mean	Ellendale, N. Dak. (444m.) Mean	Ellendale, N. Dak. (444m.) Departure from 10-yr. mean	Groesbeck, Tex. (141m.) Mean	Groesbeck, Tex. (141m.) Departure from 9-yr. mean	Royal Center, Ind. (225m.) Mean	Royal Center, Ind. (225m.) Departure from 9-yr. mean	Washington, D. C. (7m.) (mean)
Surface	21.8	+2.0	22.3	+1.7	10.3	−2.9	24.0	+1.3	15.3	−1.1	21.1
250	21.7	+2.0	21.9	+1.6			23.1	+1.3	15.1	−1.0	18.9
500	20.2	+2.3	19.3	+1.3	9.9	−2.9	21.2	+1.2	12.9	−0.8	16.9
750	19.0	+2.1	17.8	+1.5	8.1	−3.0	19.9	+1.3	11.4	−0.6	15.0
1,000	17.6	+1.9	16.3	+1.5	6.6	−3.0	19.3	+1.8	10.2	−0.4	13.4
1,250	17.0	+2.4	14.5	+1.3	5.4	−2.8	19.4	+2.8	9.2	+0.1	11.8
1,500	16.7	+3.3	12.5	+0.8	4.3	−2.4	19.3	+3.6	8.1	+0.4	10.4
2,000	14.3	+3.6	9.6	+0.6	2.2	−1.6	17.9	+4.4	6.3	+1.1	7.4
2,500	11.3	+3.4	6.9	+0.6	−0.2	−1.0	15.5	+4.6	4.1	+1.4	4.8
3,000	8.0	+3.2	3.4	+0.1	−2.8	−0.8	12.6	+4.5	1.3	+1.4	
3,500	4.3	+2.6	−0.3	−0.5	−5.9	−1.1	10.6	+5.5	−1.7	+1.3	
4,000	0.5	+2.0	−3.2	−0.3	−9.0	−1.1			−4.8	+1.2	
4,500	−3.4	+1.1			−12.3	−1.0			−7.6	+1.1	
5,000									−11.0	+0.8	

RELATIVE HUMIDITY (%)

Surface	70	0	58	−4	75	+14	75	+3	72	+8	52
250	70	0	58	−4			77	+4	72	+8	55
500	67	−1	60	−3	75	+14	79	+5	74	+10	57
750	65	−2	59	−5	76	+16	78	+5	76	+12	57
1,000	65	−1	59	−5	76	+16	73	+3	76	+12	57
1,250	59	−5	61	−4	76	+16	61	−4	72	+9	58
1,500	52	−9	63	−2	76	+16	49	−11	70	+7	59
2,000	50	−8	55	−7	73	+13	30	−22	61	+2	61
2,500	45	−10	50	−9	72	+13	23	−26	54	0	58
3,000	41	−12	53	−3	69	+12	21	−27	54	+3	
3,500	37	−15	63	+8	66	+12	19	−27	48	−2	
4,000	37	−16	64	+12	63	+11			41	−5	
4,500	46	−7			66	+13			36	−6	
5,000									38	−4	

VAPOR PRESSURE (*mb*)

Surface	18.75	+2.19	15.81	+0.78	9.39	+0.06	22.64	+2.83	12.82	+0.81	13.82
250	18.57	+2.16	15.66	+0.87			21.98	+2.94	12.91	+1.07	12.81
500	16.29	+1.85	13.96	+0.85	9.14	+0.06	20.17	+2.88	11.47	+1.26	11.67
750	14.67	+1.67	12.67	+0.74	8.26	+0.23	18.36	+2.68	10.65	+1.50	10.35
1,000	13.38	+1.47	11.58	+0.69	7.51	+0.22	15.99	+2.11	9.90	+1.57	9.43
1,250	11.55	+0.88	10.78	+0.81	6.95	+0.25	13.02	+1.03	8.77	+1.26	8.61
1,500	9.91	+0.55	9.72	+0.67	6.46	+0.36	10.28	+0.02	7.80	+1.06	8.00
2,000	7.96	+0.51	6.77	−0.40	5.34	+0.39	5.90	−1.64	6.04	+0.80	6.66
2,500	5.54	−0.21	4.84	−0.80	4.35	+0.43	3.60	−2.29	4.43	+0.56	5.08
3,000	4.10	−0.43	3.77	−0.66	3.41	+0.34	2.42	−2.40	2.56	+0.74	
3,500	2.97	−0.68	3.19	−0.37	2.63	+0.26	2.05	−1.76	2.37	+0.23	
4,000	2.08	−0.87	2.22	−0.49	2.03	+0.23			1.57	+0.13	
4,500	1.68	−0.70			1.63	+0.24			1.09	+0.04	
5,000									0.90	+0.03	

[1] Naval air station, D. C.

TABLE 2.—*Free-air resultant winds (m. p. s.) during May, 1927*

Altitude (m) m. s. l.	Broken Arrow, Okla. (233 meters) Mean Dir.	Vel.	9-year mean Dir.	Vel.	Due West, S. C. (217 meters) Mean Dir.	Vel.	7-year mean Dir.	Vel.	Ellendale, N. Dak. (444 meters) Mean Dir.	Vel.	10-year mean Dir.	Vel.	Groesbeck, Tex. (141 meters) Mean Dir.	Vel.	9-year mean Dir.	Vel.	Royal Center, Ind. (225 meters) Mean Dir.	Vel.	9-year mean Dir.	Vel.	Washington, D. C. (34 meters) Mean Dir.	Vel.	7-year mean Dir.	Vel.
Surface	S. 10°W.	5.1	S. 8°E.	2.1	S. 78°W.	3.8	S. 84°W.	1.0	N. 8°E.	2.9	N. 7°E.	0.7	S. 2°W.	5.6	S. 7°E.	2.4	S. 58°W.	1.7	S. 75°W.	0.4	N. 89°W.	0.9	N. 46°W.	0.8
250	S. 10°W.	5.3	S. 8°E.	2.2	S. 76°W.	4.2	S. 79°W.	1.1					S. 1°W.	6.1	S. 6°E.	3.0	S. 53°W.	1.8	S. 63°W.	0.4	N. 84°W.	2.0	N. 71°W.	1.8
500	S. 11°W.	6.6	S. 2°W.	3.0	S. 72°W.	6.2	S. 81°W.	1.9	N. 8°E.	2.9	N. 10°E.	0.5	S. 2°W.	7.8	S.	4.3	S. 46°W.	3.9	S. 58°W.	1.5	S. 89°W.	4.0	N. 74°W.	2.8
750	S. 14°W.	7.2	S. 7°W.	3.4	S. 78°W.	7.7	S. 82°W.	2.7	N. 19°E.	2.4	S. 61°E.	0.2	S. 3°W.	9.4	S. 7°W.	4.9	S. 49°W.	4.8	S. 68°W.	2.2	S. 85°W.	5.0	N. 72°W.	3.7
1,000	S. 25°W.	7.9	S. 22°W.	3.7	S. 79°W.	9.0	S. 85°W.	3.3	N. 26°E.	1.7	S.	0.4	S. 12°W.	10.0	S. 18°W.	5.4	S. 61°W.	5.6	S. 80°W.	2.9	S. 87°W.	5.7	N. 73°W.	4.3
1,250	S. 33°W.	8.9	S. 36°W.	4.0	S. 83°W.	10.6	S. 81°W.	4.5	N. 2°E.	0.9	S. 29°W.	0.8	S. 19°W.	9.9	S. 26°W.	5.4	S. 65°W.	7.1	S. 88°W.	3.5				
1,500	S. 47°W.	8.8	S. 47°W.	4.3	S. 81°W.	11.1	S. 78°W.	5.5	N. 37°W.	1.4	S. 41°W.	1.2	S. 26°W.	9.4	S. 33°W.	5.1	S. 66°W.	8.3	S. 85°W.	3.8	N. 82°W.	6.9	N. 68°W.	5.6
2,000	S. 59°W.	9.1	S. 63°W.	4.7	S. 78°W.	11.5	S. 80°W.	6.8	N. 63°W.	3.1	S. 64°W.	2.3	S. 28°W.	8.4	S. 45°W.	5.0	S. 75°W.	10.4	S. 87°W.	6.3	N. 83°W.	9.2	N. 71°W.	6.6
2,500	S. 65°W.	9.8	S. 70°W.	5.6	S. 77°W.	12.8	S. 81°W.	9.0	N. 87°W.	5.1	S. 67°W.	3.9	S. 36°W.	6.2	S. 59°W.	5.1	S. 81°W.	13.0	N. 88°W.	6.4	N. 85°W.	11.4	N. 71°W.	7.1
3,000	S. 80°W.	9.5	W.	6.2	S. 78°W.	12.6	S. 85°W.	8.9	N. 77°W.	8.0	S. 73°W.	5.5	S. 43°W.	5.5	S. 74°W.	6.1	N. 88°W.	15.1	N. 79°W.	8.3	S. 86°W.	13.0	N. 75°W.	7.3
3,500	S. 78°W.	12.1	N. 86°W.	7.7	N. 82°W.	12.1	N. 86°W.	10.0	N. 84°W.	11.1	S. 81°W.	6.4	S. 72°W.	8.4	S. 86°W.	7.4	N. 84°W.	14.0	N. 76°W.	8.4	N. 78°W.	13.5	N. 66°W.	7.3
4,000	S. 89°W.	12.5	N. 85°W.	8.5	N. 67°W.	13.6	N. 72°W.	11.8	S. 83°W.	11.1	N. 88°W.	8.1	W.	20.0	N. 76°W.	10.1	N. 85°W.	13.4	N. 85°W.	8.8	N. 68°W.	14.9	N. 62°W.	7.6
4,500	N. 66°W.	12.5	N. 77°W.	9.1					N. 77°W.	17.2	N. 70°W.	7.5					N. 85°W.	17.4	N. 85°W.	12.5	N. 62°W.	15.2	N. 50°W.	7.3
5,000									W.	20.0	N. 58°W.	3.2					N. 78°W.	21.1	N. 79°W.	14.4	N. 70°W.	18.2	N. 52°W.	5.5

WEATHER IN THE UNITED STATES

GENERAL CONDITIONS

The exceptional features of the month as a whole can be explained in terms of the distribution and movement of cyclonic and anticyclonic systems and the free-air temperatures. (See Aerological observation.) More or less stagnation of the former at times contributed to the heavy rainfall of the Missouri, middle Mississippi, and lower Ohio Valleys. The temperature was below normal in about one half of the country and above in the other half. (See Charts III and IV.)—*A. J. H.*

CYCLONES AND ANTICYCLONES

Fifteen LOWS and eight HIGHS were plotted during May. The only general storm area of importance developed over the Great Basin on the 6th and died out over eastern Maine on the 11th. This storm reached its maximum intensity on the 8th and 9th, with a sea-level pressure of 28.78 inches at North Platte, Nebr., at 8 p. m. of the 8th. High-pressure areas were generally unimportant; but toward the end of the month the pressure was much above the normal over the Canadian interior, and this excess of pressure was moving southward over the North Central States at the close of the month.—*W. P. Day.*

THE WEATHER ELEMENTS

By P. C. DAY, in Charge of Division

PRESSURE AND WINDS

May, 1927, as a whole was in no important sense an unusual month; still widely separated sections had rather pronounced variations in certain features from the weather usually experienced in that month.

Among the important local items of unusual conditions appear the large number of severe storms that developed in the Plateau and Rocky Mountain regions; the unusually low barometric pressures attending these in some localities and the slow rate of movement eastward; the continued cool and wet weather over most northern districts; the great deficiency in precipitation over much of Florida and some other portions of the Southeast and in portions of the Great Plains from western Kansas southward, where the wheat crop was greatly injured; the persistent high winds in portions of Texas and some other southern localities; the excessive cloudiness over the Ohio and upper Mississippi Valleys, including near-by areas; and the unusually large number of local wind and hail storms over the southern Plains and thence northeast to the Great Lakes.

The month opened with general low-pressure over the Rocky Mountain and southwestern districts, which moved into the Great Plains and Mississippi Valley during the following two or three days, but without important precipitation. By the 6th low-pressure had again entered the Southwest and on the morning of the 7th it had developed considerable strength, though without important movement, and rain or snow had set in over the districts to the northward. During the following 24 hours the storm moved to eastern Colorado with a marked increase in strength, the sea-level barometric pressure falling below 29 inches at the center and was attended by heavy snow to the northward. During the next 24 hours the storm moved slowly northeastward with undiminished intensity, heavy snow falling in the mountain districts, particularly in Wyoming, where during the 8th and 9th near-blizzard conditions prevailed, high winds and drifting snow causing the death of a number of persons and considerable loss to livestock, particularly lambs. From the 9th to 10th this storm moved with increased rapidity, but diminished intensity, to the upper Lakes and thence to the St. Lawrence Valley. Heavy snows occurred in connection with this storm over the middle and northern Rocky Mountains and near-by areas, and rainfall was widespread from the central and northern Plains eastward.

Considerable rain occurred in the central valleys and northeastern districts from the 13th to 17th as a moderate cyclone moved slowly eastward from North Dakota to New England, and some heavy rains occurred in eastern Texas and near-by areas on the 13th.

About the 17th to 19th slight cyclonic conditions overspread the central valleys and scattered rains fell in those areas and somewhat to the eastward, but no important storm development occurred.

By the 20th a well-defined storm had formed in western Colorado and during the following few days moved slowly eastward, reaching the middle Missouri Valley by the morning of the 23d, but without much precipitation save over districts to northward of the general center of the storm. During the following 24 hours low barometric centers had developed both north and south of the main storm center, which had rapidly dissipated, and by the following morning these had largely disappeared; but precipitation had covered most of the Mississippi and Ohio Valleys and near-by areas and during the following two days extended into and over most eastern districts.

During the latter part of the month storm conditions prevailed over the central Rocky Mountain and near-by areas and more or less precipitation occurred in those districts and to the northward, and on the 27th and 28th some heavy rains fell in the upper Mississippi and lower Ohio Valleys, and rain continued more or less general over the Northwest. The last few days had scattered precipitation in many portions of the country from the northern Rocky Mountains eastward and southeastward, but the rain areas were mainly small and the total falls light as a rule.

The mean sea-level pressure was highest, 30.10 to 30.15 inches, over the far Northwest, and it was above 30 inches over Florida and near-by areas. In these districts the averages were mainly above normal, but elsewhere they were less than normal and rather low on the whole over the interior and northeastern districts. Small insets on Charts I and II show the departures of the mean sea-level pressures from the normal for the month and the changes in pressure from April to May.

The month had a notably large number of severe local storms, nearly 50 having the characteristic features attending tornadoes, a number of which were distinctly severe. A total of nearly 250 lives were lost, almost 2,000 persons were injured, and property loss was estimated at more than $10,000,000. Hailstorms also were frequent, and in several instances severe loss was sustained. Full statements as to the details of several of the more severe tornadoes appear elsewhere as separate items in this issue, and the complete list of all storms, with the usual items, appears in the table at the end of this section.

TEMPERATURE

May was without important short-time variations in temperature, and while a cold month in many sections yet no important damage by frost occurred in the great agricultural regions, though in some of the important fruit districts of the far Northwest and in the central Rocky Mountain sections the temperatures were sufficiently low at times to justify taking the usual protective measures to prevent injury.

The first 10 days were mainly warmer than normal from the southern Plains eastward to the Atlantic coast and northeastward to the Great Lakes and Middle Atlantic States, but that period was mainly cooler than normal over the Northeastern States and from the upper Mississippi Valley westward and southwestward to the Pacific coast.

The week ending May 17 was distinctly cool, on the whole, from the Great Plains eastward, but correspondingly warm over the remainder of the country.

The week ending May 24 was mainly warm over all parts of the country from the middle and southern Rocky Mountains eastward to the Atlantic coast, but distinctly cool over the Northwest and moderately cool over New England and the far Southwest. The last week of May continued warm over the Southern States from eastern New Mexico to the Atlantic coast, but it continued cool in all the far West and over the northern half of the country to the eastward.

The month as a whole averaged warmer than normal over all districts from southern and central California eastward to the Atlantic coast and it was colder than normal over the remaining districts. In portions of the South, particularly in Texas, it was the warmest May of record and some areas had temperatures above normal on nearly all days. In the northern districts, however, there were few days with temperatures above normal. In these districts, however, the low means were mainly due to cloudy weather. The means of the night temperatures were generally near the normal, but the day temperatures nearly everywhere averaged several degrees lower than the normal. Over much of Texas and locally in other portions of the South it was the warmest or nearly the warmest May of record.

The warmest periods of the month were on the 1st and 2d in the Dakotas, on the 7th in Texas, on the 9th and 10th from Ohio and West Virginia eastward to the coast, about the 14th to 17th from the Rocky Mountains westward and in the middle Plains, from the 20th to 22d from Tennessee northward to Canada, on the 24th in Virginia and North Carolina, and near the end of the month in the Gulf States. The highest temperature reported was 118° in southern California, but Texas had a maximum of 115° and Arizona 114°. Over most of the Central and Eastern States the temperature did not reach 100° on any day of the month.

The coolest periods were on the 1st and 2d from Illinois eastward to the Atlantic coast and over the Northeastern and far Northwestern States, about the 8th to 10th in the Great Plains, the 11th and 12th in the Lake region, on the 16th and 17th in most Gulf and South Atlantic States, and on the 29th in California, Oregon, and Nevada.

Temperatures as low as freezing occurred over most Central and Northern States and at the high elevations of the West. The lowest reported was 1° in Wyoming.

PRECIPITATION

Rains continued frequent and occasionally heavy, as was the case during the two preceding months, over much of the Mississippi Valley region, and the total amounts for the month were above normal in all the States immediately west of the Mississippi River, in all those of the Ohio Valley, Great Lakes region and thence northeast to New England, and from the Dakotas westward to Oregon and Washington. In the Atlantic Coast States from New Jersey southward to Florida, over the Gulf States, except Louisiana and Arkansas, and from Nebraska south to Texas and thence west to the Pacific Coast the monthly precipitation was less than usually comes in May.

Precipitation was of almost daily occurrence in portions of the upper Missouri Valley, particularly in Montana, where the monthly totals were mainly the greatest for May and in some instances the greatest received in any month of record. On the other hand, in Florida the amounts were generally less than ever previously recorded in May, and as April had also been dry in many parts of the State the combined amounts for the two months at many points were less than in any other two-month period of record. The month was likewise very dry over the western portions of the Great Plains from western Kansas southward, including much of Texas, where the rainfall was the least of record for May, and much damage resulted to the wheat crop in that area.

SNOWFALL

Light snow was reported from a few points in New England and some occurred at the higher elevations of the Appalachian Mountains. Elsewhere east of the Great Plains there was little snowfall, except in the Lake Superior region and thence westward to North Dakota, where traces were reported quite generally.

In the Rocky Mountain region from northern New Mexico to Montana, including the western parts of the Dakotas and Nebraska, important amounts of snow occurred on several dates, but principally from the 7th to 9th, when heavy falls occurred at many points, particularly from Colorado northward. This period of snowfall was attended locally by high winds, much drifting, and general wintry conditions.

Considerable snow fell over much of the same area from the 18th to 22d and again near the end of the month. Total falls of nearly 5 feet occurred at some high elevations in Colorado, and similar falls occurred locally in Wyoming and Montana, while depths of from 1 to 2 feet occurred in the extreme western portions of the Dakotas. In the other Mountain States of the West snowfall was mainly light, but the prospects continued favorable for an ample supply of water for the coming summer in most districts.

RELATIVE HUMIDITY

The percentages of relative humidity were nearly everywhere greater than normal in northern districts east of the Continental Divide, notably in the Missouri and upper Mississippi Valleys, Davenport, Iowa, reporting the highest average relative humidity ever noted in May. The central valleys and some Gulf districts had averages somewhat greater than normal, also parts of Idaho, Oregon, and adjacent areas.

Deficiencies were noted in most southern districts, especially in southern California, the southern Rocky Mountain and Plains regions, the southern Appalachians and the South Atlantic States; while Los Angeles, Calif., and Roswell, N. Mex., had the lowest May averages of local record. Some parts of Washington, the interior portions of the east Gulf States, and most coast districts of the Middle Atlantic and southern New England States had slight deficiencies.

SEVERE LOCAL STORMS, MAY, 1927

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards [1]	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Williams County, N. Dak.	1–2				$5,000	Thunderstorm and wind.	Much damage to telephone and telegraph lines between Springbrook and Tioga; minor damage to buildings.	Official, U. S. Weather Bureau.
Fair Haven, Minn. (½ mile east of).	2				100,000	Tornado	Property loss confined mostly to buildings and stock; 6 persons injured.	Do.
Sallisaw, Okla.	3	9:45 a. m.	3,520		400,000	Hail	Severe crop and property damage over path 25 miles long.	Do.
Okeene, Okla. (6 miles southwest of).	4	3:30 a. m.	2,640		2,000	do	Damage chiefly to crops	Do.
Mexia to Wortham, Tex.	4	9–10	1,760		80,000	Hail, wind, and rain.	Extensive damage to oil derricks, crops, and buildings.	Do.
Americus, Ga.	4	P. m.			75,000	Electrical	Warehouse containing 1,500 bales of cotton destroyed.	Do.
Woodward County, Okla.	5	2–3 a. m.	5–10 mi.			Hail	Crops damaged considerably	Do.
Alfalfa County, Okla.	5	3:30 – 4:30 a. m.	7 mi.		700,000	Heavy hail	Severe crop and property loss; path 40 miles long.	Do.
Woods County, Okla. (northern).	5	3:45–4 a. m.	8 mi.			Hail	Considerable damage reported	Do.
Nash, Okla., and vicinity	5	4 a. m.	9 mi.		300,000	Heavy hail	Very severe crop damage over path 40 miles long.	Do.
Garfield County, Okla.	5	4:30 a. m.	5 mi.		100,000	do	Crop losses heavy; other minor damage; path 35 miles long.	Do.
Grant County, Okla.	5	5 a. m.	3 mi.		150,000	do	Damage chiefly to crops	Do.
Noble County, Okla. (northern).	5	6:30 a. m.	6 mi.		760,000	do	Crops and property damaged extensively; path 25 miles.	Do.
Christian County, Ky.	5					Wind	Several barns and much timber destroyed	Do.
Edwardsport, Ind., and vicinity.	5					Thunderstorm and wind.	Trees, electric wires, and farm property damaged; poultry killed.	Do.
Nashville, Tenn.	5					do	Lightning caused suspension of light and car service; poles and trees blown down.	Do.
Marion and Wichita, Kans.	6	2 a. m.	1,760			Heavy hail	Damage chiefly to crops and windows over path 4 miles long.	Do.
Tunica County, Miss. (central).	6	A. m.			25,000	Violent wind	Considerable property damage	Do.
Birmingham, Ala.	6	4 p. m.			5,000	Tornadic wind and thunderstorm.	Two greenhouses wrecked; 3 buildings damaged	Do.
Munday, Tex.	6	6–7:30 p. m.	11 mi.		95,000	Hail	Buildings, fruit, and gardens damaged; poultry killed or injured.	Do.
Comanche County, Kans. (10 miles west of Aetna).	7	5 p. m.				Two small tornadoes.	Area covered sparsely settled; no buildings struck.	Do.
Comanche (southeastern), Barber, Kingman, and McPherson Counties, Kans.	7	6–11:45 p. m.	880–3,520	10	1,300,000	Tornado	Hundreds of homes and a number of commercial houses demolished or damaged; overhead wires left in tangled mass; 300 persons injured; path 118 miles long.	Do.
Kansas City, Mo.	7					Thunderstorm	Street car and auto traffic demoralized; pavements damaged.	Do.
Pratt County, Kans. (southern).	7					Heavy hail	Much damage to wheat	Do.
Wyoming (eastern) and North Dakota (southwestern).	7–9			7	950,000	Snow and blizzard	Telephone and telegraph companies suffer heavy losses; electric service crippled; much loss of livestock.	Do.
Lincoln County, Nebr.	8	6–6:30 a. m.	100		50,000	Tornado	Buildings on eight farms more or less damaged or demolished; trees and poles broken off; several persons injured; path 34 miles long.	Do.
Red Willow County, Nebr. (southwest).	8	7 a. m.			10,000	Wind	Several barns and buildings wrecked; path 35 miles long.	Do.
Garfield, Greeley, and Valley Counties, Nebr.	8	2 p. m.	3 mi.			Hail	Windows broken; buds and leaves stripped from fruit trees; path 35 miles long.	Do.
Coleman, Fla. (south of)	8	4:30 p. m.	1,760		1,000	Heavy hail	Corn and tomato crops damaged about 50 per cent.	Do.
Boone, Keokuk and Woodbury, Counties, Iowa.	8	5–9 p. m.			77,500	Hail and wind	Crops and buildings damaged; poultry killed	Do.
Camden to Audrian County, Mo.	8	8–10 p. m.	200–400	10	297,000	Tornado	A number of homes and barns demolished or damaged; livestock killed; trees twisted; fruit destroyed; 51 persons injured; path 110 miles long.	Do.
Logan and Sedgwick Counties, Colo.	8–9	3–6 p. m.				High winds	Buildings and windmills damaged; poultry and foliage injured.	Do.
Texas (north-central and northeast).	8–9					do	Considerable property damage	Do.
Sheridan County, Mont.	8–9					Snow and blizzard.	Wire service crippled	Do.
Waunakee, Wis.	9	12:05 a. m.	10			Severe squall	House moved from foundation	Do.
St. Louis, Mo., and vicinity.	9	1:40 – 2:10 a. m.		1	100,000	Gale	Industrial plant damaged; houses unroofed	Do.
Nevada to Tigertown, Tex.	9	2:30 – 3:30 a. m.	300–600	[2] 39	[2] 1,000,000	Tornado	Many homes razed; crops ruined; wires down; path 45 miles long; [2] 280 persons injured.	Do.
Garland, Tex.	9	3 a. m.		([3])	([3])	do	Many persons injured; much destruction of property; part of city razed.	Do.
Peoria, Ill., and vicinity	9	6–7 a. m.	440		1,000	Hail	Glass and crops damaged	Do.
Bismarck, N. Dak. (near)	9	A. m.				Wind and rain	Windows and trees damaged; telephone and telegraph service interrupted; heavy damage by rain.	Do.
Madison, Ind. (near)	9	A. m.			120,000	do	Character if damage not reported	Do.
La Harpe, Ill. (6 miles west of).	9	1 p. m.	30			Tornado	A few outbuildings and fences wrecked; poultry killed; path 3 miles long.	Do.
Fulton County (southeast) and Schuyler County (east), Ill.	9	2 p. m.	400	1	40,000	do	A number of farm homes and barns wrecked; 12 persons injured; path 12 miles.	Do.
Randolph County Ark. (southwest), to Poplar Bluff, Mo.	9	2:15–3:20 p. m.	440–880	92	2,382,000	do	Great damage along path 60 miles long; business section of Poplar Bluff almost wiped out; 340 persons hurt.	Do.
Shreveport, La. (near)	9	2:20–2:30 p. m.	100		5,000	do	One house demolished; parts of other buildings damaged; timber blown down; path 1 mile long.	Do.
Scott to Lonoke, Ark.	9	2:30–3 p. m.			2,500	do	Character of damage not reported; path 12 miles long; 7 persons hurt.	Do.
Carlisle to Birdeye, Ark.	9	2:30–4 p. m.	400	8	60,000	do	Extensive damage over path 70 miles long; 69 persons injured.	Do.

[1] "Mi." signifies miles instead of yards.
[2] Includes deaths, amount of damage, and number injured in tornado at Garland, Tex.
[3] See note preceding.

Severe local storms, May, 1927—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Hoxie to Walnut Ridge, Ark.	9	2:50–3 p. m.	50	10	$300,000	Tornado	Storm very destructive over short path; 200 persons injured.	Official, U. S. Weather Bureau.
Racine and Kenosha Counties, Wis.	9	3–4 p. m.	20 mi.		16,000	Severe squall	Many barns demolished; roofs blown off; plate-glass windows broken; overhead-wire systems damaged.	Do.
Kingsland to Randall, Ark.	9	3:05–3:27 p. m.	50	9	30,500	Tornado	Property damage over path 20 miles long; 24 persons hurt.	Do.
Egypt, Ark.	9	3:15 p. m.	100	10	5,000	do	Considerable property damage; 8 persons hurt.	Do.
Kingston, Ark.	9	3:15 p. m.				do	Character of damage not reported	Do.
Bethsada, Ark.	9	3:20 p. m.			25,000	do	Considerable property and crop damage	Do.
Norphlet, Ark.	9	3:30 p. m.	130	1	150,000	do	Numerous structures damaged or wrecked; crops injured; 35 persons hurt.	Do.
Scott and Clinton Counties, Iowa.	9	4:05 p. m.	500–1,760		22,000	do	Damage principally to buildings and trees	Official, U. S. Weather Bureau; Moline (Ill.) Dispatch.
Morrisonville (5 miles east of) to Decatur (near), Ill.	9	4:25 p. m.	100–880	1	1,125,000	do	Public utilities sustain severe losses; heavy damage to farm homes; commercial buildings and residences; path 45 miles long; 116 persons injured.	Official, U. S. Weather Bureau.
Owaneco, Ill. (1 mile north of).	9	4:25 p. m.	200		20,000	do	Chief damage to farm property over path 5 miles long.	Do.
Strong, Ark.	9	4:25 p. m.	300	24	500,000	do	Central section of town devastated; 72 persons hurt.	Do.
Clarence, La. (near)	9	4:30 p. m.	150	1		do	Several houses and considerable timber blown down.	Do.
Carterville, Ill. (1 mile southwest of).	9	5 p. m.	100–880		343,000	do	Many buildings and a number of greenhouses wrecked or damaged; path 16 miles long; 21 persons injured.	Do.
Calvin, La. (near)	9	6:30 p. m.	800		5,200	Tornado preceded by hail.	Damage chiefly to timber; path 8 miles long.	Do.
Massac County, Ill. (western).	9	6:30 p. m.	440–880	5	56,000	Tornado	Farm property, orchards, and crops damaged; 11 persons injured; path 15 miles long.	Do.
Chicago, Ill., and vicinity	9	P. m.		4		Thunderstorm and wind.	Trees uprooted; light poles blown down; overhead signs and windows broken; basements flooded; traffic impeded in some sections.	Do.
Eden, Ill. (near)	9	P. m.	220		10,000	Small tornado	One house unroofed; other minor damage; path short.	Do.
De Kalb, De Witt, Fulton, Grundy, Kane, Lake, McHenry, and Madison Counties, Ill.	9	P. m.		1	638,000	High winds	Many commercial buildings and residences damaged; small houses wrecked; telephone, telegraph, and light poles prostrated; cottages at summer resorts demolished; 7 persons hurt.	Do.
Beckett Mountain, Ark. (Faulkner County).	9				1,000	Small tornado	Minor damage	Do.
Fredonia, Wis.	9					Tornadic wind, hail, and cloudburst.	Soil washed; trees felled	Green Bay Press Gazette (Wis.).
Hartley, Iowa	9				50,000	Tornado	Residences and smaller buildings wrecked; trees torn or uprooted.	Journal (Sioux City, Iowa).
Kankakee Valley, Ind.	9				100,000	Thunderstorm with tornadic characteristics.	Extensive damage to farms, telephone, and telegraph service.	Official, U. S. Weather Bureau.
Michigan (western)	9					Thunderstorms, wind, and a small tornado.	Public utilities crippled; chicken industry hurt; tornado occurred near Grand Rapids, where a barn and auto were wrecked and livestock killed.	Do.
Pauls Spur to Pierce's Mill, Ark.	9			4		Tornado	No damage reported	Do.
Trezevant and Ripley, Tenn.	9				5,000	Wind	Trees uprooted; small buildings unroofed	Do.
Seneca and Cayuga Counties, N. Y.	10	11:30 a. m.	2–6 mi.			Wind and hail	Windows broken, roofs pierced; chimneys, overhead wires, and small buildings damaged.	Do.
Livingston Manor, N. Y.	10	3:30 p. m.				Heavy hail	Windows and roofs badly damaged	Do.
Washington County, Md. (central).	10	4–5 p. m.			50,000	Wind and hail	Crops, fruits, and gardens damaged	Do.
Baltimore, Md.	10	6:21 p. m.				Wind	Trees blown down; roofs blown off	Do.
Charles County, Md. (southern).	10	7 p. m.			3,000	Hail and wind	Crops injured; poultry killed barn unroofed	Do.
Union County, N. J.	10	7:30 p. m.				Wind	Some frame buildings demolished	Do.
Berkeley County, W. Va.	10					Wind and hail	Roofs and shade trees damaged	Do.
Columbia, S. C. (near)	11	P. m.	10 mi.			Series of hail storms.	Crops in path practically destroyed	Do.
Fort Davis, Tex.	12	2 p. m.	3 mi.			Hail	Crops and apple orchards injured; path — miles long.	Do.
Scotland, Robeson, and Pitt Counties, N. C.	12		1,760		100,000	Heavy hail	Cotton, tobacco, and corn injured; on some farms crops will require replanting.	Do.
Alexander and Pulaski Counties, Ill.	13	12:30–2:30 p. m.	3–8 mi.		5,000	Hail	Fruit damaged	Do.
Embarrass and Belle Plains, Wis.	13	2 p. m.	10 mi.			Heavy hail	No damage reported	Do.
Keokuk County, Iowa	13	2 p. m.	440		3,000	Tornado	Path 3 miles long; character of damage not reported.	Do.
Pike County, Ind. (eastern)	13				13,000	Tornadic wind	Farm properties damaged	Do.
Washington, D. C. (northeast part of).	14	6 p. m.	10			Small tornado	Slight damage over path ½ mile long	Do.
Portland, Oreg., and vicinity	15–17					Wind	Several buildings wrecked, others damaged; many trees and windows broken.	Do.
Liberty to Sherman County, Mont.	17	11 a. m.–1:30 p. m.				Hail and rain	Young crops and fruit trees injured	Do.
Roy, N. Mex. (near)	17	4:20 p. m.	300			Tornado	Farm property damaged; chickens carried away and some stock killed; path 5 miles long.	Do.
Butler, Cherokee, Franklin, Grundy, Monroe, and Tama Counties, Iowa.	17	8:40–11 p. m.			43,500	Hail	Crops beaten; buildings damaged	Do.
Ensign, Kans. (near)	17					Tornado	Large barn demolished	Do.
Rosebud County, Mont.	17					Wind	Some buildings unroofed	Do.
Davenport, Iowa	18	A. m.				Hail	Extensive damage to greenhouses	Do.
Peoria, Ill., and vicinity	18	1:30–2:05 p. m.	10 mi.		6,000	do	Chief damage to greenhouse; some injury to crops.	Do.
Buchanan County, Iowa	18	4 p. m.	40		18,000	do	Character of damage not reported	Do.
Barrow, Ill. (near)	18	4:30 p. m.	40		200	Tornado	Minor property damage over short path	Do.
Terre Haute (near) to Indianapolis, Ind.	18	7:45 p. m.		2	3,077,000	Tornadic wind	Many homes damaged, some totally wrecked; public utilities suffer heavy losses; hundreds of autos wrecked; 100 persons injured, 6 seriously; greatest damage in Indianapolis.	Do.

Severe local storms, May, 1927—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Randall County, Mo. Renick to Evansville (near).	18	8-9 p. m.	67-333		$7,000	Tornado	Two dwellings blown from foundations, 3 barns badly damaged; path 10 miles long.	Official, U. S. Weather Bureau.
Anna, Ill.	18	11:15 p. m.	30		10,000	Tornadic wind	Twelve or more houses damaged; several garages wrecked; trees broken; 3 persons injured.	Do.
Ayers, Canton, and Rantoul, Ill.	18					Wind	Numerous buildings damaged; trees and poles blown down; 15 persons hurt.	Do.
Bronson, Tex.	19		3,520		5,000	Hail	Character of damage not reported	Do.
Winnsboro, La.	19-20					Wind	Considerable timber blown down	Do.
Vernon County, Wis. (northern).	20	2:45 p. m.	5 mi.		7,500	Severe squall and small tornado.	A barn, 2 boathouses, 4 silos, and 2 tobacco sheds damaged; small tornado near Stoddard.	Do.
Sheboygan, Wis.	20	6 p. m.			3,000	Severe squall	Damage principally at Brotz airport	Do.
Clayton, Fayette, and Green Counties, Iowa.	20				3,500	Wind and hail	Fruit and other crops damaged	Do.
Harrison County, Iowa	21	1:30 a. m.			5,500	do	Buildings damaged; livestock killed or injured	Do.
Clayton, Wis. (near)	21	5:30 a. m.	1,760		3,000	Severe squall	Damage mostly to buildings, crops not far advanced.	Do.
Ballston Lake, N. Y.	22	5 p. m.	4 mi.			Heavy hail	Truck crops and fruit hurt	Do.
Chicago, Ill.	23	11 a. m.				Thunderstorm and wind.	Small buildings unroofed; plate-glass windows broken; trees and wires down.	Do.
Balmorhea, Tex.	23	2:30 p. m.	5 mi.			Hail	Cotton crop damaged about 30 per cent; alfalfa injured; path 10 miles long.	Do.
Williamsburg, Iowa (near)	23	6 p. m.	440	2		Tornado	Property damaged over path 6 miles long	Do.
Allamakee County, Iowa	23	10 p. m.			2,500	Hail	Windows and roofs damaged	Do.
Hannibal, Mo.	23	P. m.				Thunderstorm and wind.	Trees broken; many local and long-distance telephones out of use.	Do.
Fort Wayne, Ind.	23					Wind	Trees, telegraph, telephone, and power lines affected.	Do.
Howard, Kosciusko, and White Counties, Ind.	23				25,000	do	Crops, buildings, and trees damaged	Do.
Illinois (northern)	23				10,000	do	Minor damage to trees, poles, roofs, etc	Do.
Roosevelt, Okla. (4 miles southwest of).	23		3 mi.		9,000	Hail	Damage to crops and property about equal; path 7 miles long.	Do.
Bourbon, Crawford, and Neosho counties, Kans.	23-24		50 mi.			Violent winds	Barns and small buildings wrecked; wire systems damaged.	Do.
Concordia, Kans. (near)	24	A. m.	1,760		40,000	Heavy hail	Wheat, oats, and alfalfa beaten to ground; path 8 miles long.	Do.
St. Joseph, Mo.	24	5:18 a. m.			200,000	Tornado	Much destruction over path 2 blocks wide through business section; considerable damage to residences and trees; 2 persons hurt.	Do.
Quincy, Pa.	24	5-6 p. m.	3,520		15,000	Thunderstorm	Damage chiefly to growing crops; many fields washed out.	Do.
Bartholomew and Sullivan Counties, Ind.	24				45,000	Wind	Character of damage not reported	Do.
Batavia and Geneva, Ill., and vicinity.	24					do	Trees and buildings damaged; 1 person injured	Do.
Grant County, Wis. (southeast).	24		20 mi.			Severe squall	Farm property damaged	Do.
Delaware County, Iowa	25	3 p. m.		1		Wind and hail	Buildings damaged	Do.
Doran, Ill. (near)	25	3:45 p. m.	440-880		50,000	Tornado	Buildings wrecked; orchards injured; livestock killed; 80 telephone poles down; path 10 miles long.	Do.
Sussex County, Md.	25	4 p. m.	2-6 mi.			Hail	Truck gardens and crops injured	Do
Somerset to Worcester County, Md.	25	4-5 p. m.	8 mi.			Wind	Buildings at fair grounds and on some farms damaged; shade and fruit trees blown down; other property damage at seashore.	Do.
Palestine, Ill. (near)	25	5 p. m.	440		20,000	Tornado	Property damaged over path 13 miles long; 2 persons injured.	Do.
Knox County (northeast) to Daviess County (northwest), Ind.	25				200,000	Wind and hail	3,000 acres of wheat ruined	Do.
Moultrie County, Ill.	25				3,000	Wind	Buildings damaged	Do.
Norfolk, Va.	25			6	15,000	Severe squall	Roof at ball park partly blown off; many trees and poles blown down; 37 persons injured.	Do.
Paoli, Ind.	25					Heavy hail	Truck gardens and crops hurt	Do.
Caroline County (southern) to Dorchester County (northern), Md.	26	2 p. m.				Hail	Considerable crop damage	Do.
Archer and Raleigh, Fla.	26	2-3 p. m.	3,520		10,000	do	Poultry and small animals killed or injured; tomatoes, corn, and melons ruined.	Do.
Philadelphia, Pa.	26	2-3 p. m.				Thunder squall	Circus tent collapsed, injuring 3 persons; considerable minor damage to insecure structures.	Do.
Furnas County, Nebr. (northwest).	26	6 p. m.			7,000	Hail and wind	Character of damage not reported	Do.
Nuckolls (northwest) and Webster (central) Counties, Nebr.	26	8 p. m.			20,000	do	Windmills and a few farm buildings wrecked	Do.
Furnas County, Nebr. (northern).	26	10:30 p. m.	880		2,000	Straight wind	One large barn and several small outbuildings demolished.	Do.
Harrison County, Iowa	26	11 p. m.			7,000	Hail and wind	Character of damage not reported	Do.
Garrett County to Washington County, Md.	26		10-25 mi.		25,000	Hail	Crops, roofs, and windows damaged over path 70 miles long.	Do.
Parkersburg, W. Va. (6 miles south of).	26					do	Some damage to truck gardens	Do.
Trenton, N. J.	26					Violent gust	Office building swayed	Do.
Lincoln, Nebr., and vicinity	26-27				60,000	Severe thunderstorm and wind.	Much damage to trees and buildings in city; light and telephone lines down.	Do.
Hamilton, York, Seward, Fillmore, and Saunders Counties, Nebr.	27	Midnight to 1:30 a. m.	40 mi.		65,000	Hail	3,600 square miles' damage light to heavy at various points; path 90 miles long.	Do.
Auburn, Calif.	27	4 p. m.	440			do	Crop loss about 10 per cent	Do.
Warren County, Iowa	27	4 p. m.			6,000	Tornado	Character of damage not reported	Do.
Chase County, Nebr. (central).	27	4:30 p. m.				do	Gardens injured over path 6 miles long	Do.
Randolph County, Mo. (north of Roanoke to near Higbee).	27	5 p. m.	440	5	100,000	do	Many dwellings and barns destroyed along path 10 miles long; some livestock killed.	Do.
Chico, Calif.	27	7-7:30 p. m	880			Hail	Crops, especially vegetables, damaged	Do.
Franklin County, Nebr. (northern).	27	8-8:30 p. m.	3,520		5,000	Hail and wind	Some farm buildings wrecked; crops injured	Do.
Cass, Madison, Pocahontas, Pottawattamie, and Shelby Counties, Iowa.	27				32,000	Wind	Damage chiefly to buildings; storms usually occurred in the morning.	Do.
Dubois County, Ind. (southern).	27					Hail	Storm very destructive to crops	Evansville Courier (Ind.).

Severe local storms, May, 1927—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Grayson County, Ky	27				$100,000	Hail and wind	Barns and timber destroyed	Official, U. S. Weather Bureau.
Haskell, Tex. (near)	27		4 mi.			Hail	Crops destroyed	Do.
Tybee Island, Ga	28	7:50 p. m.			1,000	Wind	Some property damage	Do.
Christian, Sangamon, Madison, St. Clair, and Montgomery Counties, Ill.	28	P. m.			776,000	Hail and electrical.	Damage principally to property other than crops.	Do.
Columbia, S. C	28				3,000	Thunderstorm	Dwelling burned	Do.
Jonesboro, Ark	28				1,500	Heavy hail	Glass in greenhouses broken; also other minor damage.	Do.
St. Louis, Mo., and vicinity	28					do	Extensive damage chiefly to greenhouses and windows.	Do.
Harrison County, Iowa	29	12:30 a. m.			1,000	Wind	Buildings damaged	Do.
Charleston, S. C., and vicinity.	29	P. m.				Severe squall	Considerable damage to trees in city; a few small buildings moved from foundations.	Do.
Stillwarter County, Mont. (eastern).	29					Hail	Heavy damage to winter wheat and alfalfa	Do.
Munday, Tex	30	6 p. m.			280,000	do	Extensive damage to crops, buildings, and fruit and shade trees.	Do.
Elizabethton, Tenn	30					Heavy hail	Crops severely beaten; other property damaged	Do.
Fulton County, Ky	30			1	50,000	Hail and wind	Crop loss about 50 per cent; poultry killed; other property damage.	Do.
Hannibal, Mo. (northwest of).	30	P. m.	880		2,500	Hail	Orchards and gardens injured	Do.
Ridge Springs, S. C. (near)	31	5 p. m.	1,760		2,500	do	Dwellings and crops damaged; poultry injured	Do.
Red Bluff, Calif. (14 miles south of).	31	P. m.			100,000	Heavy hail	Orchards and grains damaged	Do.
Waverly, Tenn	31				20,000	Hail and wind	Crops and other property damaged	Do.

STORMS AND WEATHER WARNINGS

WASHINGTON FORECAST DISTRICT

May was an unusually quiet month in the Washington forecast district. No storm warnings were issued, and the month was also remarkably free from frosts. Small craft warnings were ordered displayed on only two dates. These warnings were for the Atlantic coast from Cape Hatteras northward and were issued on the 10th and 27th.

Warnings of frost, mostly light, were issued for limited areas in the Northeastern States on seven days during the month. With the exception of killing fost at Northfield, Vt., on the 8th, and heavy frost at the same place on the 9th, and at Scranton, Pa., and Binghamton, N. Y., on the 29th, all frosts reported during the month were light; and no frost was reported south of Pennsylvania, Ohio, and West Virginia. Only one heavy frost occurred in the cranberry bogs of New Jersey.—*C. L. Mitchell.*

CHICAGO FORECAST DISTRICT

The month, as a whole, in the Chicago forecast district was cool and wet, with the exception of the middle Great Plains, where it was rather dry and comparatively warm. The rainfall was excessive in the Ohio Valley, and the amount was unusual even in the northern plains. The storm areas appeared to move across the district with relatively slow movement, and with their centers well to the south, thus producing more than the ordinary rainfall.

The principal storms were as follows:

One which developed in the far West early in the month and remained nearly stationary for a few days and finally advanced across the district on the 8th, 9th, and 10th, accompanied by general rains and thunderstorms and strong shifting winds and squalls, and followed by a considerable fall in temperature, with frosts in the Plains States to the southern limit of Kansas on the 11th, and in the upper Mississippi Valley and western Lake region on the 12th. Warnings were displayed on the Great Lakes in advance of this storm, and warnings for frosts in the area following.

Another storm developed in the far West on the 16th and 17th and remained practically stationary for several days, and finally passed across the district on the 22d-26th. Although this disturbance was of marked intensity in its original development, it lost considerable force as it passed eastward, and in consequence only small craft warnings were displayed on the Great Lakes.

Still another storm appeared immediately in the far West, and the movement eastward of this also was very slow, the passage across the district not being completed until the closing days of the month; but the precipitation attending this storm was more or less spotted and the attendant winds of not much importance. Cool weather, however, immediately followed, and frosts occurred in the upper Mississippi Valley and western Lake region, warnings for which were issued on May 31.

There were other storms, of course, of lesser importance, regarding which nothing need especially be said.

Special service was given to a number of interests during the month in the shape of detailed predictions, but the most important by far were flying forecasts for certain routes, including one for Capt. Charles A. Lindbergh, for his flight from St. Louis to New York on May 12; for Commander F. de Pinedo, flying from New Orleans to Memphis on May 14, Memphis to Chicago on May 15, and Chicago to Montreal on May 17; for the First Pursuit Group, Army Air Corps, from Selfridge Field to Kelly Field on May 2 to 8, inclusive, and return May 21 to 23, inclusive; and special forecasts on May 30 and 31 for zones 4 and 8 for the national elimination balloon race.

Special forecasts for frost warnings for the cranberry marshes of Wisconsin were issued from time to time, beginning May 4. These were for the most part fully verified.—*H. J. Cox.*

NEW ORLEANS FORECAST DISTRICT

Storm warnings were displayed on the Texas coast, May 7 and 12, and on the eastern part of that coast on the 21st, and subsequent conditions justified these warnings except that verifying velocities did not occur following the warning of the 21st. Small craft warnings were displayed on different parts of the west Gulf coast on the 8th, 9th, 10th, 11th, 12th, 20th, and 21st, and subsequent winds showed that the warnings were well placed.—*I. M. Cline.*

DENVER FORECAST DISTRICT

The month was cold and stormy in Montana, northern Wyoming, and northern Utah. Temperatures above normal, with a deficiency in precipitation, prevailed in southeastern Wyoming, Colorado, southern Utah, Arizona, and New Mexico.

In addition to the usual LOWS from the North Pacific a number of disturbances advanced eastward from the southern Rocky Mountain and Plateau regions, several of which attained unusual intensity. The first of these advanced to eastern Colorado on the evening of the 7th. At 8 a. m. of the 8th the barometer at Pueblo had fallen to 28.92 inches (sea level), with precipitation in nearly all portions of the district. Heavy rain or snow fell during the day in central and eastern Colorado, eastern Wyoming, and eastern Montana, and gales were experienced from New Mexico northward to Wyoming during the slow northeastward movement of the storm. This disturbance was followed by freezing temperatures in Montana, Wyoming, northern and western Colorado, north-central and northeastern Arizona, and southern and eastern Utah.

Another storm of marked intensity advanced eastward across the district from the southern portion of the Rocky Mountain region during the period from the 18th to the 22d. General rain or snow fell in Montana, Wyoming, and Utah, with gales in the southeastern portion of the district. Freezing temperatures again occurred on the southern portion of the Plateau from the 22d to the 25th and in western Colorado on the 23d and 24th.

Rain or snow in the northern portion of the district also resulted from the final notable storm of the month which moved across the district from the 25th to the 29th. Freezing temperatures occurred on the 29th and 30th in portions of western Colorado, north-central and northeastern Arizona, and Utah.

Special wind forecasts, principally in the interest of aviation, were issued for Colorado and Wyoming, or portions of these two States, on the evenings of the 1st, 6th, 19th, 20th, and 21st, and on the mornings of the 8th, 17th, and 20th. These were generally verified.

Frost or freezing temperature warnings, which received general verification, were issued on the 2d, 3d, 8th, 9th, 10th, 14th, 18th, 20th, 21st, 22d, 23d, 24th, 28th, 29th, and 30th for those portions of the district where they were needed.—*J. M. Sherrier.*

SAN FRANCISCO FORECAST DISTRICT

Except for several days of unusual warmth about the middle of May, temperatures over the district as a whole were below normal for the greater part of the month, and numerous warnings of light to moderately heavy frost were required for the elevated regions lying to the eastward of the Cascade and Sierra Nevada Mountains. On a few of these occasions, early in the month, conditions were extreme enough to require protective measures in the orchard sections of eastern Washington and light firing was done in the Rogue River Valley of western Oregon on one occasion.

Storm warnings were issued for north coast points on two dates, the 1st and 11th, when disturbances of rather unusual intensity for so late a month approached from the Gulf of Alaska. The first of these passed directly inland attended by winds of gale force north of Cape Blanco. The behavior of the second was more characteristic of the month of May; it halted upon reaching the coast, to redevelop later in milder form over the interior of Canada. Strong winds along the Washington coast, however, accompanied its approach, and gales were undoubtedly experienced at sea.—*E. H. Bowie.*

RIVERS AND FLOODS

By H. C. FRANKENFIELD

The great Mississippi flood continued during the month and, as has been stated before, a complete report thereon will be made at a later date.

Atlantic and east Gulf drainage.—The only flood reported was a very moderate local one in the upper Tombigbee River of Mississippi. It lasted only two days, only a few acres of the lowest river bottoms were covered, and the damage was negligible.

Ohio drainage.—The interior rivers of Ohio, Indiana, and Kentucky were high during the last decade of the month, with a great flood in the extreme upper Kentucky River, and another but somewhat less severe one in the Wabash River of Indiana. The Kentucky River flood was caused by excessive rains during the night of May 29–30, the amount ranging from 4 to 4.5 inches and probably more in some places. At times the rate of fall was from 1 to 1.5 inches per hour, with the heaviest fall, greatest loss of life, and most destructive flood conditions along the North Fork of the Kentucky River. The number of persons missing or known to have been drowned was 89, and incomplete reports indicated a loss and damage total of between $6,000,000 and $7,000,000. At Hazard, Ky., alone the losses amounted to $2,000,000, of which perhaps 75 per cent were railroad losses. Both highway bridges were swept away as the river reached a stage of 36.98 feet, 15.98 feet above flood stage, at 11 a. m. May 30, and the Louisville & Nashville Railroad Co. lost 15 bridges, mainly on branch lines in Letcher County. The flooded area covered the district from Morgan County on the north to Harlan County on the south and thence eastward to the State line. As the flood began during the night, many homes were surrounded by water before the inmates became aware of the danger, and for many there was no possibility of escape. Ten or fifteen thousand people were made homeless, and perhaps 20,000 idle through enforced suspension of business, mostly coal mining, and to the reported losses there must also be added a few millions on account of loss of wages. The river at Hazard according to old residents was about 1 foot higher than in 1862, the highest known water previous to 1927.

The Wabash River flood was still in progress at the end of the month, and report thereon will be made later. Prospective losses will be considerable as the delay in spring planting may mean the loss of an entire crop in the river bottoms.

The floods in the interior rivers of Ohio were very moderate. Warnings were issued promptly and there were no losses of consequence. There were also moderate floods in the Ohio River between Evansville, Ind., and Shawneetown, Ill., and in the Green River of Kentucky. These floods caused no material damage and they subsided during the first week in June. Their principal effect was to further delay farming operations in the bottom cornlands.

A very severe rain and hailstorm during the early morning of May 30 in Johnson, Carter, Sullivan, and Greene Counties, Tenn., and Lee, Scott, Washington, and Smith Counties of southwestern Virginia caused a decided rise in the three forks of the Holston River, the drowning

of five persons, and much property damage. For a time the rains were torrential, and the rapid rise in the waters was followed by an equally rapid recession. It was impossible to issue warnings for the floods that occurred, and the losses amounted to about $75,000, of which about $25,000 were in crops.

Mississippi drainage.—Moderate floods during the fourth week of May in the Mississippi River between Quincy, Ill., and Louisiana, Mo., and in the lower Des Moines River of Iowa were well forecast, and actual damage was about $14,000 only. There was further delay in farming operations and some business inconvenience.

Missouri drainage. There was a flood in the Missouri River beginning on May 10 at Pierre, S. Dak., and ending at Kansas City, Mo., on May 18. From the mouth of the Cheyenne River in South Dakota to Sioux City, Iowa, the rise was the greatest of record for the month of May, and the stages reached were the highest since July, 1905. Heavy precipitation for six weeks over South Dakota, beginning with March 31, had thoroughly saturated the soil, and when on May 5 heavy rains set in over the drainage areas of the Cheyenne, Bad, White, and Niobrara Rivers, all, especially the Cheyenne and Bad, were soon in flood. At Fort Pierre, on Bad River, the flood was very serious, with losses amounting to $174,250. Total reported losses from Pierre to Sioux City, Iowa, were $353,750, of which $197,250 represented losses of prospective crops. Value of property saved through warnings given by the Weather Bureau, $99,000. No estimate could be made of losses of fine farmlands that were taken up by the changing river channel, a phenomenon peculiar to the Missouri River. Probably several thousand acres were lost.

In the Omaha, Nebr., district the flood was more moderate, and, while there was much inconvenience, reported losses were only about $45,000, excluding, however, that which will ultimately result from losses of prospective crops. Reports indicate that between 40,000 and 50,000 acres of farmlands were affected, which at a conservative estimate of $12 an acre would make the prospective losses between $500,000 and $600,000. Money value of property saved through the warnings was given as more than $250,000.

In the Kansas City, Mo., district the flood was very moderate and the losses were almost entirely prospective.

Arkansas drainage.—Rains between May 5 and 7 over eastern Kansas caused rapid rises in the rivers and a few unimportant floods in the Osage and upper Neosho, Cottonwood, and Ninescah Rivers. Warnings were issued as soon as possible, with resulting crop damage amounting to about $7,000, and minor losses of about $400. Property valued at $2,000 was reported as having been saved through the warnings.

West Gulf drainage.—The upper Trinity River of Texas was in rather high flood early in May. It was not especially dangerous, however, and apparently loss and damage were very small.

The Rio Grande remained above flood stage at San Marcial, N. Mex., throughout the month. Thus far no damage has been reported.

Pacific drainage.—The Colorado River was in moderate flood at Fruita, Colo., and below Grand Canyon, Ariz., for a few days only at Fruita, but quite generally below Grand Canyon. While the floods were not serious, heavy rains with high temperatures could easily make them so, and special forecasts and warnings for the lower river were distributed twice each week, as well as on several other occasions when important changes were indicated. There were also important rises in the tributary streams in the State of Colorado and in the San Juan River of New Mexico. Warnings were issued at the proper time, and no reports of loss or damage were received.

The annual rise of the Columbia River began during the month, but no flood stages had been reached by the end of the month except at Vancouver, Wash., and also in the Willamette River at Portland, Oreg., where the flood stage of 15 feet was passed on May 20. A report on this rise will be made at a later date.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
Atlantic drainage					
	Feet			*Feet*	
Susquehanna: Oneonta, N. Y.	12	25	25	12.1	May 27
East Gulf drainage					
Tombigbee: Aberdeen, Miss.	33	9	9	34.3	10
Mississippi drainage					
Ohio:					
Shawneetown, Ill.	35	31	(2)		
Cairo, Ill.	45	(1)	5	56.4	Apr. 20
Tuscarawas:					
Gnadenhutten, Ohio	9	20	21	11.3	May 21
Coshocton, Ohio	8	20	21	9.0	20
Walhonding: Walhonding, Ohio	8	20	20	11.5	20
Scioto:					
Larue, Ohio	11	19	20	14.6	19
Prospect, Ohio	10	20	21	12.8	21
Bellpoint, Ohio	9	20	20	9.1	20
Circleville, Ohio	10	20	22	12.2	21
Chillicothe, Ohio	16	22	22	16.1	22
Kentucky:					
Hazard, Ky.	21	30	30	37.0	30
Beattyville, Ky.	30	31	(2)	34.8	31
Wabash:					
Bluffton, Ind.	11	20	22	13.5	21
Lafayette, Ind.	11	19	28	20.2	20
Covington, Ind.	16	19	(2)	24.1	21-22
Terre Haute, Ind.	16	21	(2)	20.9	30
Vincennes, Ind.	14	24	(2)	22.0	30
Mount Carmel, Ill.	16	22	(2)		
Tippecanoe: Norway, Ind.	6	(1)	12	6.5	3-5
		18	(2)	6.5	19
White: Decker, Ind.	18	24	(2)		
White, West Fork:					
Anderson, Ind.	12	19	20	15.2	20
Noblesville, Ind.	14	19	21	16.8	20
Indianapolis, Ind.	18	20	20	18.1	20
Elliston, Ind.	19	21	31	23.1	24
Edwardsport, Ind.	15	20	(2)	18.4	26 and 30
Holston: Rogersville, Tenn.	14	31	(2)	17.2	31
Holston, North Fork: Mendota, Va.	8	31	31	8.0	31
Mississippi:					
Quincy, Ill.	14	25	(2)	15.3	26
Hannibal, Mo.	13	20	21	14.1	20
		25	(2)	15.7	26
Louisiana, Mo.	12	25	(2)	14.7	27
Grafton, Ill.	18	(1)	4	25.8	Apr. 25
		10	13	19.2	May 11
		25	(2)	21.1	30
Alton, Ill.	21	(1)	4	31.2	Apr. 25
		9	13	23.6	May 11
		26	(2)	23.9	29
St. Louis, Mo.	30	(1)	1	30.1	Apr. 28
		11	11	30.3	May 11
Chester, Ill.	27	(1)	3	34.5	Apr. 26
		29	(2)	27.8	May 30
Cape Girardeau, Mo.	30	(1)	6	40.0	Apr. 20-21
		10	(2)	32.8	May 12
New Madrid, Mo.	34	(1)	16	43.5	Apr. 21-22
Memphis, Tenn.	35	(1)	19	46.0	23
Helena, Ark.	44	(1)	23	56.8	26-27
Arkansas City, Ark.	48	(1)	10	60.5	21
Greenville, Miss.	42	(1)	10	54.7	21
Vicksburg, Miss.	45	(1)	(2)	58.7	May 4
Natchez, Miss.	46	(1)	(2)	56.5	1 and 4
Angola, La.	45	(1)	(2)	57.5	15-17
				47.8	15
Baton Rouge, La.	35	(1)	(2)		16-17
Donaldsonville, La.	28	(1)	(2)	37.1	
New Orleans, La.	17	(1)	(2)	21.0	Apr. 25

[1] Continued from last month.
[2] Continued at end of month.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
Mississippi drainage—Continued					
Illinois:	*Feet*			*Feet*	
Morris, Ill.	13	(1)	1	14.4	Apr. 30
		21	29	17.9	May 25
Peru, Ill.	14	(1)	(2)	23.2	Apr. 21
				22.8	May 26
Henry, Ill.	10	(1)	(2)	17.9	Apr. 23-24
				17.4	May 28
Peoria, Ill.	18	(1)	(2)	24.6	Apr. 23-24
				23.9	May 28
Havana, Ill.	14	(1)	(2)	22.3	Apr. 26
				21.4	May30-31
Beardstown, Ill.	14	(1)	(2)	25.2	Apr. 26
Pearl, Ill.	12	(1)	(2)	22.7	26-27
Meramec:					
Steelville, Mo.	12	25	25	17.7	May 25
Pacific, Mo.	11	26	29	18.3	27
		31	(2)		
Valley Park, Mo.	14	10	10	15.6	10
		26	(2)	21.0	28
St. Francis:					
St. Francis, Ark.	17	(1)	(2)	26.4	Apr. 18
Marked Tree, Ark.	17	(1)	(2)	20.1	May 10
Missouri:					
Pierre, S. Dak.	13	10	10	14.7	10
Chamberlain, S. Dak.	14	11	11	15.0	11
Yankton, S. Dak.	12	11	13	13.5	12
Blair, Nebr.	16	12	17	19.2	14
Omaha, Nebr.	19	14	16	19.9	15
St. Joseph, Mo.	12	16	17	12.1	16
Hermann, Mo.	21	10	10	21.3	10
St. Charles, Mo.	25	9	11	27.1	10
Floyd: Merrill, Iowa	13				
Arkansas:					
Pine Bluff, Ark.	25	(1)	3	32.4	Apr. 21
Yancopin, Ark.	29	(1)	(2)	48.5	20
Neosho: Oswego, Kans.	17	8	10	17.6	May 8
Cottonwood: Emporia, Kans.	20	8	10	22.7	9
White:					
Georgetown, Ark.	22	(1)	4	30.3	Apr. 17
Clarendon, Ark.	30	(1)	12	43.3	23
Black:					
Leeper, Mo.	11	25	25	11.9	May 25
Williamsville, Mo.	11			14.5	25
Poplar Bluff, Mo.	14	7	8	14.5	7
		26	28	17.2	27
Corning, Ark.	11	(1)	(2)	16.2	Apr. 18
Petit Jean: Danville, Ark.	20	11	11	20.3	May 11
		21	21	20.3	21
Cache: Patterson, Ark.	9	(1)	8	16.0	Apr. 19
		18	19	9.0	May 18-19
Yazoo: Yazoo City, Miss.	25	(1)	(2)	37.4	5
Tallahatchie: Swan Lake, Miss.	25	(1)	(2)	31.8	Mar. 22
				31.1	Apr. 26–May 1
Red:					
Fulton, Ark.	28	(1)	1	35.0	Apr. 24
Springbank, Ark.	37	(1)	2	30.2	27-28
Ouachita: Monroe, La.	40	(1)	(2)	48.2	May 4
Atchafalaya:					
Melville, La.	37	(1)	(2)	46.8	14-16
Morgan City, La.	8	26	(2)		
West Gulf drainage					
Sabine: Logansport, La.	25	(1)	7	29.2	Apr. 19
Trinity:					
Dallas, Tex.	25	(1)	1	33.1	21
		9	9	26.4	May 9
Trinidad, Tex.	28	(1)	6	36.7	Apr. 29
Liberty, Tex.	25	(1)	11	27.4	21
Rio Grande: San Marcial, N. Mex.	2	(1)	(2)	3.8	May 9, 10, 21
Pacific drainage					
Colorado:					
Fruita, Colo.	12	19	23	12.2	19-21
Topock, Ariz.				19.6	27
Parker, Ariz.	7	1	(2)	10.0	28
Gunnison: Delta, Colo.	9	(1)	8	9.9	1
		14	28	10.8	17-18
Gunnison, North Fork: Paonia, Colo.	9	(1)	(2)		
		18	21	9.1	18
San Joaquin: Friant, Calif.	12	14	18	12.9	17
Kings, Piedra, Calif.	12	5	5	12.0	5
		14	19	13.3	17
Columbia: Vancouver, Wash.	15	20	24	16.2	21-22
		28	(2)		
Willamette: Portland, Oreg.	15	20	(2)		
Clearwater: Kamiah, Idaho	14	17	17	14.6	17

[1] Continued from last month.
[2] Continued at end of month.
[3] Below flood stage at 8 a. m. May 1, 1927.

MEAN LAKE LEVELS DURING MAY, 1927

By UNITED STATES LAKE SURVEY

[Detroit, Mich., June 4, 1927]

The following data are reported in the Notice to Mariners of the above date:

Data	Lakes [1]			
	Superior	Michigan and Huron	Erie	Ontario
Mean level during May, 1927:	*Feet*	*Feet*	*Feet*	*Feet*
Above mean sea level at New York	601.96	579.14	571.95	245.95
Above or below—				
Mean stage of April, 1927	+0.55	+0.36	+0.20	−0.02
Mean stage of May, 1926	+1.78	+0.98	+0.78	+0.58
Average stage for May, last 10 years	+0.32	−0.99	−0.39	−0.30
Highest recorded May stage	−1.09	−4.38	−2.47	−3.00
Lowest recorded May stage	+1.78	+0.98	+0.78	+0.99
Average departure (since 1860) of the May level from the April level	+0.31	+0.30	+0.34	+0.33

[1] Lake St. Clair's level: In May, 1927, 574.40 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, MAY, 1927

By J. B. KINCER

General summary.—During the first decade rains interrupted field work in most of the interior valley States, although considerable was accomplished the first part. Lowlands continued too wet for good growth of crops, with further complaint of grains yellowing, while conditions in the Northwest were rather unfavorable. In the central and southern Great Plains the weather was rather favorable, and in the South mostly ideal conditions prevailed for field work; but it continued too dry in the Southeast and in parts of the Southwest, with a general, soaking rain needed in the former area and in parts of Texas, Oklahoma, and sections to the westward. There was further delay to field work during the second decade, due to wet soil and further rainfall, and spring planting was much behind an average season in much of the Ohio Valley and central Mississippi areas. Vegetation made slow progress, due to cool weather, in the East, but good advance was reported in the West wherever there was sufficient soil moisture. A continuation of rains kept the soil too wet for working in the Ohio and middle Mississippi Valleys during the latter part of the month, and the continued absence of rain in the Southeast and Southwest was unfavorable, with moisture urgently needed in much of these areas.

Small grains.—It was rather unfavorable for wheat during the first part of the month. The winter crop continued to make fair to very good progress in some sections, but further rains were detrimental in many interior valley districts, especially on lowlands, and there were further complaints of yellowing. Little seeding could be accomplished in the Spring Wheat Belt, but the early seeded grain made satisfactory progress. Winter wheat continued to make good to excellent advance in most of the Great Plains during the second decade, but was poor in Oklahoma due to rust, insect infestation, and scanty

moisture, while drought was damaging in western Kansas. Further deterioration continued in these sections during the latter part of the month, but elsewhere the crop made mostly fair to very good progress. Harvest advanced in Texas and at the close of the month wheat was heading as far north as Pennsylvania. Oats did well during most of the month, except in some interior wet sections. Conditions were favorable for rice generally and flax seeding progressed fairly well, except for some local interruption by rain.

Corn.—Considerable corn planting was accomplished in the Ohio Valley States during the first part of the month, but rains interrupted this work toward the close of the first decade. Planting made very good progress in many sections of the upper Mississippi Valley, but was much behind an average season. Seeding was slow and very backward and had become seriously delayed in most of the Ohio Valley States at the close of the month. It made generally good advance in the Great Plains area, with cultivation progressing in southern sections.

Cotton.—Planting cotton advanced well generally, except in some central-northern portions of the belt and in the inundated sections, although planting was progressing on some of the higher ground in the previously overflowed territory at the close. The continued absence of rain in the eastern portion of the belt was generally unfavorable and resulted in rather poor germination and slow progress of the planted crop. Progress and condition of cotton were rather poor in Texas during the first half with deterioration in the drier sections, but conditions were more favorable during the latter half, with progress ranging from fair to very good; the condition of the crop varied greatly, from poor to very good. The early planted stood the drought well, but late planted in the drier districts deteriorated, with germination poor in the west and north. Growth was fair to good in most other sections, and the crop was clean and generally well cultivated.

Ranges, pastures, and livestock.—Continued dry weather was unfavorable in the Southwest and caused some deterioration, especially in New Mexico and adjacent sections, where the range was barren in many parts. Generally good to excellent condition of the range prevailed in most of the Great Plains area and pastures were uniformly good in the East, except in the Southeast, where it was too dry. Some livestock losses occurred from stormy weather and the poor range caused much to be shipped out in New Mexico, but elsewhere livestock were generally good.

Miscellaneous crops.—Potato planting progressed to the northern border States, but this work was retarded the latter part of the month by continued rains or wet soil. Progress of potatoes was generally good in most sections where up, but sweet-potato transplanting was delayed in the Southeast by continued dry weather. Minor crops suffered from lack of moisture in most sections from Florida northward to North Carolina and condition in this area was poor, with much truck reported a failure on the Florida uplands. In most other sections of the country truck made generally good advance. Tobacco was affected by the drought in Florida and continued wet soil in Kentucky made conditions unfavorable for transplanting. Sugar-beet seeding was finished in Wyoming, with the early crops being thinned, and elsewhere they were growing well.

Fruits were generally good in most northern sections, although the early crop was showing the effects of the April freeze. Citrus continued to drop badly in Florida during most of the month due to continued absence of moisture, but this crop did well in California.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

The number of gales reported during May was not far from the normal shown on the Pilot Chart over the greater part of the steamer lanes, where in different 5° squares they were observed on from two to four days. Moderate conditions were the rule off both the American and European coasts, with the exception of a few days. In the region between the thirtieth and thirty-fifth parallels and the twenty-fifth and sixty-fifth meridians the number of days with heavy weather was somewhat in excess of the normal.

May was an exceptionally foggy month, especially over the Grand Banks and off the American coast, as fog was reported on 18 days in the former locality and on from 14 to 15 in the latter. There was also more fog than usual over the eastern section of the steamer lanes, where it occurred on from 3 to 9 days.

The results for Julianehaab, Greenland, were not given in the following table, as reports were missing on 10 days. Judging from data on hand there was a period of high pressure from the 13th to 15th, with a barometric reading of 30.12 inches on the former date; cyclonic conditions prevailed on the 21st, when a reading of 29.53 inches was recorded; the reports for the 22d and 23d are missing.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (seventy-fifth meridian), North Atlantic Ocean, May, 1927*

Stations	Average pressure	Departure [1]	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Belle Isle, Newfoundland	29.83	−0.11	30.20	5th.	29.48	9th.
Halifax	29.92	−0.08	30.44	22d.	29.48	26th.
Nantucket	29.92	−0.09	30.46	22d.	29.50	27th.
Hatteras	29.98	−0.03	30.36	22d.	29.76	16th.
Key West	30.02	+0.04	30.14	31st.	29.90	1st.[2]
New Orleans	30.01	+0.05	30.18	31st.	29.84	28th.
Swan Island	29.88	+0.01	29.98	[2] 23d.	29.80	2d.
Turks Island	30.07	+0.07	30.14	13th.	29.96	28th.
Bermuda	30.08	+0.08	30.30	[2] 10th.	29.86	28th.
Horta, Azores	30.06	−0.08	30.32	9th.	29.78	18th.
Lerwick, Shetland Islands	30.02	+0.22	30.48	10th.	29.57	21st.
Valencia, Ireland	30.06	+0.11	30.42	11th.	29.54	2d.
London	30.05	+0.13	30.42	11th.	29.66	31st.

[1] From normals shown on H. O. Pilot Chart, based on observations at Greenwich mean noon, or 7 a. m., seventy-fifth meridian.
[2] And on other dates.

On the 1st a disturbance of limited extent was central near Hatteras, and moderate to strong northerly gales prevailed in that vicinity. On the 1st there was also a depression central near 50° N., 35° W., that afterwards increased considerably in intensity. The western LOW moved northeastward along the coast, and on the 2d the center was near Sydney, Nova Scotia. The eastern

disturbance of the 1st had moved about 5° toward the eastward during the next 24 hours, and on the 2d moderate gales prevailed over the middle section of the steamer lanes, as well as the region between the Bermudas and fortieth parallel.

An area of low pressure was in the vicinity of Nova Scotia and Newfoundland on the 3d and 4th, respectively, and on the latter date westerly gales prevailed in the southerly quadrants, and also between the fortieth meridian and the Azores. This LOW then moved rapidly eastward and on the 5th and 6th was central near 46° N., 40° W., while on both dates northerly to northwesterly gales occurred between the thirty-fifth and fiftieth meridians.

From the 7th to 10th an area of low pressure lay over the western section of the Gulf of Mexico, and on the 8th and 9th winds of force 7 were encountered west of the 90th meridian.

Charts VIII to X cover the period from the 8th to 10th, inclusive, and give an idea of the conditions at the time of the airplane flight of Captain Nungesser.

From the 11th to 23d there were no disturbances of any extent or intensity, although a few reports of moderate gales were received, and areas of low pressure covered different sections of the ocean during this period.

Charts XI to XIII cover the period from the 19th to 21st, inclusive, showing the weather on the day before and on the two days included in Colonel Lindbergh's flight.

On the 24th St. Johns, Newfoundland, was near the center of a LOW that afterwards developed into the most severe disturbance of the month. On the 25th and 26th the center was near 45° N., 40° W., and on both of these dates severe westerly to northwesterly gales swept over the region between the fortieth and fiftieth parallels and and the thirty-fifth and sixtieth meridians.

From the 27th until the end of the month moderate weather prevailed generally, except that on the 28th northwest winds of force 7 occurred in the vicinity of New York, and from the 29th to 31st moderate northerly gales were reported from a limited area east of the twenty-fifth meridian.

OCEAN GALES AND STORMS, MAY, 1927

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
North Atlantic Ocean			° ′	° ′				*Inches*					
Olancho, Hond. S. S.	Puerto Cortez	New York	33 50 N.	76 00 W.	May 1	3a., 1	May 1	29.63	N.	NNE., 7	N.	N., 9	Steady.
Conte Rossa, Ital. S. S.	Naples	do	38 01 N.	63 00 W.	do	Mdt., 1	May 2	29.55	SW.	SW., 10	NNW.	SW., 10	SW.-NNW.
Veendam, Du. S. S.	Rotterdam	do	48 40 N.	37 42 W.	do	8p., 1	do	29.20	SW.	WSW., 8	W.	WNW., 9	WSW.-NNW.
Mar Negro, Span. S. S.	Swansea	Montreal	48 06 N.	29 15 W.	do	Noon, 2	May 3	29.35	SE.	WNW., 2	ENE.	WSW., 10	SE.-WNW.-ENE.
Steel Seafarer, Am. S. S.	Port Said	New York	38 47 N.	55 40 W.	May 4	10a., 4	May 4	29.83	W.	W., 7	NW.	NW., 9	W.-NW.
Providence, Fr. S. S.	Lisbon	Providence	40 25 N.	16 10 W.	do	8a., 4	do	29.85	SSW.	Var.	SW.	WNW., 9	
Mar Negro, Span. S. S.	Swansea	Montreal	45 15 N.	44 30 W.	May 5	9p., 5	May 6	29.32	SW.	W., 8	NW.	NW., 11	SW.-W.-NW.
Gonzenheim, Ger. S. S.	Emden	Portland, Me.	46 11 N.	42 14 W.	May 6	5a., 6	do	29.06	NNW.	NNW., 8	NNW.	—, 11	Steady.
North Cornwall, Br. S. S.	Genoa	Montreal	44 43 N.	31 00 W.	do	4a., 7	May 7	29.32	SW.	SW., 9	WNW.	SW., 9	SW.-W.-WNW.
Cherea, Ital. S. S.	Palermo	New York	36 18 N.	57 55 W.	May 7	1a., 8	May 8	29.46	SW.	W., 9	NW.	—, 9	SW.-W.-S.-NW.
Clontarf, Am. S. S.	Gibraltar	do	36 00 N.	44 13 W.	May 8	Mdt., 8	May 9	29.82	SSW.	S., 9	W.	S., 9	S.-SSW.
North Cornwall, Br. S. S.	Genoa	Montreal	45 40 N.	38 00 W.	do	3a., 9	do	29.31	SSE.	SSW., 9	W.	SSW., 9	SSE.-S.-W.
Laura C. Ital. S. S.	Gibraltar	New York	35 04 N.	34 25 W.	May 12	10p., 12	May 14	29.97	NW.	NW., 6	NNW.	NW., 8	NW.-NNW.
Dakarian, Br. S. S.	Galveston	Liverpool	49 16 N.	22 27 W.	May 16	3a., 16	May 17	29.71	E.	E., 8	E.	—, 8	
Middleham Castle, Br. S. S.	Antwerp	Habana	39 36 N.	29 06 W.	May 17	Noon, 17	May 18	29.73	NW.	NW., 7	NE.	NNE., 8	NW.-NNE.
Burgerdijk, Du. S. S.	Rotterdam	New York	41 03 N.	57 50 W.	May 19	8a., 19	May 20	29.78	SSW.	SW., 8	WNW.	SW., 8	Steady.
New York City, Br. S. S.	Cardiff	Philadelphia	43 50 N.	42 37 W.	May 23	2p., 24	May 26	28.84	SSE.	SW., 11	WNW.	SW., 11	S.-WNW.
Deutschland, Ger. S. S.	Southampton	New York	45 30 N.	37 15 W.	May 25	4p., 25	do	29.29	SW.	SW., 9	W.	WNW., 11	SW.-WNW.
Stockholm, Swed. S. S.	Gothenburg	do	46 54 N.	42 48 W.	do	1p., 26	do	29.02	SW.	W., 11	NW.	W., 11	SW.-W.-NW.
North Pacific Ocean													
Esther Dollar, Br. S. S.	Karatsu	San Francisco	46 50 N.	152 15 W.	May 1	2a., 1	May 2	29.58	NE.	N., —	NW.	N., 8	NE.-N.-NW.
Do	do	do	43 42 N.	143 00 W.	May 4	2a., 4	May 4	29.98	SSE.	SSE., —	SW.	SSE., 8	SSE.-SW.
Mayebashi Maru, Jap. S. S.	Kobe	New York	45 05 N.	144 04 W.	May 1	8a., 2	May 3	29.72	SSW.	SSW., 8	WNW.	WSW., 9	SW.-WSW.
Hayo Maru, Jap. S. S.	Miike	Bellingham	48 59 N.	126 08 W.	May 2	2a., 3	do	29.64	SE.	SE., —	S.	SE., 10	SE.-S.
Pres. Taft., Am. S. S.	Yokohama	Victoria	50 00 N.	153 00 W.	May 4	2a., 5	May 6	29.71	SSE.	SSE., 8	S.	SSE., 8	Steady.
City of Vancouver, Br. S. S.	Vancouver	Osaka	50 06 N.	174 52 E.	May 6	1p., 8	May 9	29.30	SE.	SW., 6	W.	WSW., 8	
Oakridge, Am. S. S.	Yokohama	Portland	49 02 N.	163 15 W.	May 9	6p., 10	May 11	29.54	WNW.	WNW., 7	NW.	WNW., 9	WNW.-NW.
Tahchee, Br. S. S.	Shanghai	San Pedro	47 00 N.	157 30 E.	May 16	4a., 17	May 17	29.27	ENE.	NE., 7	NE.	NE., 8	ENE.-NE.
Alabama Maru, Jap. S. S.	Yokohama	Victoria	39 45 N.	149 55 E.	do	4p., 16	May 18	29.17	W.	WNW., —	NNE.	NW., 8	W.-NW.-NNE.
Montague, Am. S. S.	Hong Kong	San Francisco	45 41 N.	167 10 E.	do	8p., 16	May 19	29.47	E.	E., 9	NW.	E., 9	Steady.
West Hixton, Am. S. S.	Niigata	Portland	43 29 N.	147 25 E.	May 23	Mdt., 23	May 24	29.32	W.	W., 8	W.	W., 8	Steady.
West Nomentum, Am. S. S.	Columbia River.	Yokohama	45 46 N.	159 21 E.	May 24	Noon, 24	do	29.35	S.	SW., 8	W.	SW., 8	S.-SW.
Pawlet, Am. S. S.	Hong Kong	San Francisco	36 30 N.	143 40 E.	do	10a., 24	May 25	29.59	ENE.	E., 8	NE.	E., 8	ENE.-E.
West Cayote, Am. S. S.	Dairen	Columbia River.	48 48 N.	163 32 W.	May 29	6p., 30	May 31	28.97	E.	E., —	SSE.	E., 9	Steady.
West Hixton, Am. S. S.	Niigata	Portland	49 45 N.	170 06 W.	May 30	6a., 31	do	29.58	N.	NW., —	NW.	NNW., 8	NNW.-NW.
South Pacific Ocean													
Tahita, Br. S. S.	San Francisco	Sydney	37 20 S.	161 43 E.	May 12	4p., 12	May 13	29.58	S.	WSW., 1	SSW.	SSW., 8	N.-WSW.
Mojave, Am. S. S.	Buenos Aires	San Pedro	50 02 S.	77 12 W.	May 18	4a., 20	May 20	29.26	SW.	WNW., 7	SW.	W., 11	SW.-NW.
South Atlantic Ocean													
Sabotawan, Am. S. S.	Santa Fe, Arg.	Wilmington, Del.	28 10 S.	45 00 W.	May 7	7a., 8	May 8	29.04	E.	SW., 8	W.	NE., 9	NW.-SW.
Mojave, Am. S. S.	Buenos Aires	San Pedro	38 32 S.	57 20 W.	May 11	1a., 12	May 12	29.89	W.	SW., 8	S.	SW., 8	W.-SW.
Lorraine Cross, Am. S. S.	Mobile	Montevideo	27 50 S.	44 50 W.	May 7	7a., 8	May 9	29.22	NW.	SW., 9	SW.	SW., 9	W.-SW.
Do	do	do	34 45 S.	53 50 W.	May 12	4a., 12	May 13	29.84	NW.	NW., 8	SW.	SW., 8	NW.-SW.
West Neris, Am. S. S.	Buenos Aires	Santos	31 56 S.	49 45 W.	do	10a., 12	do	29.93	W.	W., 7	WSW.	WSW., 8	W.-WSW.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

The average pressure during May, 1927, was close to normal over a great part of the North Pacific Ocean. A long, shallow trough of low pressure—the Aleutian LOW—covered the western part of the Gulf of Alaska and the southeastern part of Bering Sea, and extended southwestward along the Aleutian Islands, with the minimum reading, 29.85 inches, at Kodiak. An anticyclone, almost unbroken by cyclonic influences, except for slight intrusions from the northward, covered the eastern and central part of the ocean from the American coast to beyond the one hundred and eightieth meridian. On the China coast cyclonic conditions normal to the season prevailed, the continental anticyclone of the cooler season having by this time entirely disappeared.

Pressure data for certain American island and coast stations in west longitudes are found in the following table:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean, May, 1927*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Dutch Harbor [1]	29.87	−0.05	30.58	24th	29.20	9th.
St. Paul [1]	29.94	+0.08	30.48	24th	29.38	8th.
Kodiak [1 4]	29.85	−0.02	30.36	5th	29.18	10th.
Midway Island [1]	30.16	+0.07	30.34	6th [4]	29.92	1st.
Honolulu [2]	30.06	+0.01	30.14	14th	29.93	25th.
Juneau [3]	30.01	+0.02	30.40	13th	29.57	11th.
Tatoosh Island [2 3]	30.07	+0.03	30.44	13th	29.55	1st.
San Francisco [2 3]	30.03	+0.05	30.23	11th	29.72	25th.
San Diego [2 3]	29.95	+0.02	30.08	11th	29 81	5th.

[1] P. m. observations only.
[2] A. m. and p. m. observations.
[3] Corrected to 24-hour mean.
[4] For 30 days.
[5] On other date.

At Honolulu easterly winds prevailed. The average hourly velocity was 10.4 miles, and the maximum velocity was 36 miles from the east on the 15th.

Generally speaking, May was a quiet month over most of the North Pacific. High winds, that is, gales exceeding 7 in force, were rare south of the fortieth parallel, vessels within this great region reporting fresh to strong gales only, and these limited to the coast regions off the Peninsula of California on the 21st and 22d, and east of Honshu on the 16th and 24th. Gales were more frequent to the northward of the fortieth parallel, yet nowhere exceeded 8 or 9 in force, except on the 3d, when a whole gale was experienced off Vancouver Island by the Japanese steamer *Hayo Maru* previous to the passage of a small cyclone into the coast of British Columbia. A further small cyclone in this vicinity on the 17th caused a 56-mile westerly wind at Tatoosh Island.

Fresh to strong gales occurred early in the month between 42° and 50° north latitude, 130° and 155° west longitude. During the second decade gales were experienced on various days along the upper steamship routes west of 160° west longitude, but were mostly concentrated from the 12th to the 17th over a region roughly bounded by latitudes 45° and 50° N., longitudes 155° and 175° E., south and southeast of Kamchatka. The last week in May witnessed gales in upper mid-ocean south of the eastern Aleutians, and over a comparatively small area east of Honshu and the Kuril Islands.

Fog was more frequent in May than in April, except perhaps along the American coast, where there was little change from that of the previous month. The 12th to the 17th were the most general days with it between the central Californian coast and Cape San Lucas. Away from the coast, along the upper half of the route between Seattle and Honolulu, dense wet fogs were encountered from the 12th to the 14th, and from the 22d to the 25th. Along the northern steamship routes there were a number of foggy days in west longitudes; but they were more frequent from the western Aleutians to the coast of Japan, over a considerable part of which area fog occurred on 25 to 40 per cent of the days, which is above the average there for May.

CLIMATOLOGICAL TABLES[1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, May, 1927

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	73.1	+1.8	2 stations	99	[2] 27	St. Bernard	38	17	2.55	−1.42	Bridgeport	5.45	Coffee Springs	0.52
Arizona	68.3	+1.1	2 stations	114	14	Alpine	16	22	0.15	−0.15	Henry's Camp	1.09	29 stations	0.00
Arkansas	71.7	+2.7	Portland	97	[2] 29	Dutton	32	16	6.54	+1.52	Higden	14.03	Arkansas City	1.68
California	60.6	0.0	Greenland Ranch	118	15	Ellery Lake	8	29	0.60	−0.50	Steele Swamp	3.30	25 stations	0.00
Colorado	54.6	+2.7	Lamar	103	17	2 stations	8	[2] 8	0.81	−0.94	Savage Basin	3.10	Springfield	0.00
Florida	77.2	+1.6	Lake Alfred	102	31	2 stations	42	[2] 16	0.93	−3.03	Belle Glade	3.19	3 stations	T.
Georgia	73.6	+2.0	Alapaha	104	31	2 stations	34	17	1.58	−1.92	Blue Ridge	3.98	St. George	0.07
Idaho	50.4	−2.4	Chattin's Flat	102	16	Obsidian	9	2	2.20	+0.47	Grangeville	7.66	Driggs	0.50
Illinois	61.2	−1.4	Mount Carmel	92	21	Joliet	32	1	6.95	+2.94	Fairfield	12.05	Waukegan	3.54
Indiana	61.1	−1.1	Madison	94	21	Hobart	28	1	7.09	+3.08	Paoli	12.13	Angola	2.97
Iowa	58.4	−1.8	2 stations	91	17	4 stations	30	[2] 5	4.69	+0.08	Independence	9.07	Oakland	0.86
Kansas	65.5	+2.0	2 stations	105	17	Cawker City	26	11	1.91	−1.92	Chanute	6.17	Ulysses	0.04
Kentucky	65.7	+0.1	2 stations	93	21	2 stations	31	17	7.44	+3.47	Blandville	12.36	Greenup	3.32
Louisiana	76.1	+2.5	Dodson	100	31	Lake Providence	46	1	5.42	+0.99	Grand Coteau	16.38	Donaldsonville	2.05
Maryland-Delaware	61.7	−0.9	Cumberland, Md	95	9	Oakland, Md	28	1	3.05	−0.54	Cambridge, Md	6.39	Pocomoke City, Md.	1.70
Michigan	52.2	−1.6	Cassopolis	97	22	2 stations	20	[2] 12	4.21	+1.04	Scottville	11.71	Adrian	1.84
Minnesota	51.2	−3.5	Lynd	88	21	Itasca State Park	25	11	3.66	+0.56	2 stations	6.06	Sandy Lake Dam	1.07
Mississippi	73.9	+2.4	Aberdeen	99	29	2 stations	42	16	4.56	−0.02	Tupelo	10.59	Shubuta	2.09
Missouri	64.6	0.0	2 stations	94	[2] 28	2 stations	34	12	6.98	+2.28	Morehouse	13.62	Kidder	1.46
Montana	46.7	−4.2	Ennis	88	16	Poker Jim Ranger Station.	7	10	5.15	+2.92	Adel	10.82	Libby	1.02
Nebraska	59.0	0.0	McCook	104	17	2 stations	22	[2] 9	2.48	−1.07	Purdum	6.16	Guide Rock	0.44
Nevada	55.9	−0.8	Logandale	108	16	Rye Patch	14	29	0.55	−0.28	Arthur	2.11	6 stations	0.00
New England	51.3	−3.6	Fitchburg, Mass	83	[2] 21	2 stations	21	[2] 2	3.78	+0.39	Farmington, Me	6.76	Plymouth, Mass	1.35
New Jersey	58.1	−2.3	2 stations	88	[2] 10	2 stations	30	[2] 8	3.65	−0.21	Chatham	8.16	Phillipsburg	1.93
New Mexico	62.9	+3.1	Nara Visa	105	18	3 stations	19	[2] 11	0.12	−0.97	Boaz	1.20	58 stations	0.00
New York	54.0	−1.8	Dansville	93	22	2 stations	20	1	4.73	+1.19	Carmel	7.51	Chazy	2.40
North Carolina	68.0	+1.3	Weldon	100	24	Mount Mitchell	18	12	2.50	−1.51	Banners Elk	6.57	Southport	0.48
North Dakota	48.0	−4.6	New England	87	1	Westhope	13	6	5.62	+3.07	Pembina	9.30	Wahpeton	2.60
Ohio	60.1	−0.4	Portsmouth	95	[2] 9	Medina	26	1	4.73	+1.04	Ohio State University.	7.63	Montpelier	2.19
Oklahoma	71.7	+4.0	Waurika	108	28	2 stations	32	[2] 9	2.72	−2.19	Sallisaw	7.51	Boise City	0.00
Oregon	51.5	−2.2	Pilot Rock	97	15	Fremont	14	29	2.13	+0.08	Bull Run Lake	9.54	Umatilla	0.12
Pennsylvania	58.2	−1.3	3 stations	92	[2] 9	West Bingham	23	28	4.14	+0.15	Elk Lick	7.23	Philadelphia	1.75
South Carolina	71.4	+0.4	Garnett	103	31	2 stations	36	17	1.92	−1.61	Blackville	4.40	Aiken	0.29
South Dakota	52.9	−2.6	Academy	89	2	Camp Crook	17	10	5.14	+1.81	McLaughlin	9.27	Hardy Ranger Station.	1.27
Tennessee	68.8	+2.1	Etowah	94	20	Rugby	32	17	5.06	+0.96	Kingsport	9.69	Charleston	1.80
Texas	77.7	+4.6	Fort McIntosh	115	7	Dalhart	31	10	1.63	−2.03	Bon Wier	6.09	13 stations	0.00
Utah	54.0	−0.7	St. George	101	15	Castle Rock	15	[2] 10	0.97	−0.34	High Line City Creek.	4.39	18 stations	0.00
Virginia	64.3	+0.2	Winchester	95	24	Burkes Garden	24	2	2.87	−1.34	Mendota	7.75	New Canton	1.17
Washington	51.3	−2.7	Wahluke	92	15	2 stations	20	[2] 2	2.63	+0.74	Wynoochee power plant.	14.07	Fort Simcoe (near)	0.03
West Virginia	62.0	−0.3	3 stations	95	[2] 9	White Sulphur Springs.	21	1	4.13	+0.04	Davis	7.74	Upper Tract	0.75
Wisconsin	52.1	−2.6	Kilbourn	91	21	Big St. Germain Dam.	17	12	4.46	+0.65	Darlington	7.57	Blair	2.17
Wyoming	47.9	−1.8	3 stations	90	16	2 stations	1	[2] 9	2.33	+0.20	Dull Center (near)	9.40	Eden	0.20
Alaska (April)	29.3	−3.7	Wonder Lake	62	10	Fort Yukon	−41	6	3.23	−1.15	Fortmann Hatchery	10.27	Fort Yukon	0.03
Hawaii	72.8	+1.2	Waianae	96	7	Volcano observatory	51	[2] 1	8.45	+2.67	Hiloa-Manawai-opuna Divide.	53.50	2 stations	0.00
Porto Rico	77.5	−1.1	2 stations	96	[2] 2	Jayuya	53	5	7.13	+2.38	Bayamon	16.34	Santa Isabel	0.45

[1] For description of tables and charts, see REVIEW, Jan. 1927, p. 43.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, May, 1927*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
New England							52.5	−2.2										75	3.00	−0.4											7.0		
Eastport	76	67	85	29.80	29.88	−.08	45.7	−2.0	64	29	52	34	1	39	24	42	39	80	2.25	−1.6	17	6,588	s.	37	ne.	15	1	7	23	8.3	T.	0.0
Greenville, Me	1,070	6	----	28.74	29.90	----	46.8	----	72	30	57	26	1	37	38	----	----	----	6.70	----	18	4,952	se.	26	nw.	27	3	6	22	----	3.5	0.0
Portland, Me	103	82	117	29.81	29.93	−.04	50.2	−3.1	74	26	57	36	2	44	28	46	42	74	3.66	0.0	17	5,924	e.	29	w.	28	5	7	19	6.7	0.0	0.0
Concord	289	70	79	29.60	29.91	−.07	51.6	−2.7	75	29	62	28	2	41	40	----	----	----	2.89	−0.4	13	3,822	nw.	23	sw.	18	7	3	21	7.3	0.0	0.0
Burlington	403	11	48	29.45	29.89	−.08	51.8	−4.7	74	22	60	31	1	43	31	----	----	----	3.16	+0.3	17	7,181	s.	40	s.	10	2	7	22	8.1	0.0	0.0
Northfield	876	12	60	----	29.92	−.05	49.3	−3.5	77	22	60	25	8	39	38	----	----	73	1.79	−1.0	14	5,645	s.	34	s.	16	2	11	18	7.6	0.0	0.0
Boston	125	115	188	29.77	29.91	−.07	55.2	−1.9	77	11	62	41	1	48	27	49	43	68	2.50	−1.0	15	5,999	e.	28	nw	27	5	11	15	6.9	0.0	0.0
Nantucket	12	14	90	29.90	29.90	−.09	52.2	−0.1	66	26	58	41	2	46	18	48	46	84	1.64	−1.0	17	10,623	sw.	43	ne.	30	7	8	16	6.8	0.0	0.0
Block Island	26	11	46	29.87	29.90	−.09	53.0	+0.2	64	26	58	42	2	48	18	49	46	84	1.92	−1.8	16	10,547	sw.	39	nw.	2	8	9	14	6.2	0.0	0.0
Providence	160	215	251	29.74	29.91	−.07	55.6	−2.9	75	26	64	38	1	47	25	50	44	67	2.76	−0.7	14	7,899	nw.	48	nw.	2	6	13	12	6.5	0.0	0.0
Hartford	159	122	----	29.74	29.91	−.07	56.1	−1.4	78	11	64	42	5	48	27	----	----	----	5.80	+2.3	16	----	nw.	----	----	----	6	12	13	6.4	0.0	0.0
New Haven	106	74	153	29.80	29.92	−.07	56.3	−1.6	73	11	64	42	28	48	24	51	46	71	4.64	+1.0	17	6,351	sw.	35	sw.	15	8	13	10	5.9	0.0	0.0
Middle Atlantic States							60.8	−1.2										74	3.04	−0.5											6.6		
Albany	97	102	115	29.79	29.90	−.08	56.3	−3.0	77	22	65	38	3	48	28	51	47	74	2.92	−0.1	19	5,397	s.	26	s.	10	6	13	12	6.4	0.0	0.0
Binghamton	871	10	84	28.97	29.90	−.08	55.4	−2.0	85	22	65	31	1	46	37	----	----	----	5.60	+2.5	20	4,320	w.	30	w.	26	2	12	17	7.7	0.0	0.0
New York	314	414	454	29.58	29.92	−.07	58.0	−2.6	77	23	65	44	28	51	27	51	46	71	3.67	+0.5	14	10,978	e.	54	nw.	27	4	12	15	6.7	0.0	0.0
Harrisburg	374	94	104	29.53	29.92	−.06	59.4	−2.4	80	10	68	40	1	51	27	53	48	70	2.72	−1.0	17	4,760	sw.	31	s.	10	3	8	20	7.4	0.0	0.0
Philadelphia	114	123	190	29.81	29.94	−.05	61.6	−1.3	82	10	70	43	1	53	26	56	54	82	1.75	−1.4	13	6,149	sw.	38	sw.	10	3	14	14	7.0	0.0	0.0
Reading	325	81	98	29.57	29.91	----	59.4	----	82	10	68	41	1	51	28	53	47	67	2.73	−0.6	16	2,266	se.	24	nw.	15	6	8	17	7.2	0.0	0.0
Scranton	805	111	119	29.06	29.92	−.06	56.2	−3.2	81	22	65	37	1	47	39	52	48	77	4.47	+1.0	17	4,962	s.	30	sw.	26	3	10	18	7.1	0.0	0.0
Atlantic City	52	37	172	29.87	29.93	−.05	57.5	−0.6	80	23	63	43	1	52	27	53	50	80	3.29	+0.3	15	11,402	s.	46	s.	10	7	13	11	5.8	0.0	0.0
Cape May	17	13	49	29.93	29.95	−.04	59.4	+0.8	78	11	67	43	1	52	24	56	54	88	2.41	----	10	----	nw.	----	----	----	----	----	----	----	----	0.0
Sandy Hook	22	10	55	29.90	29.92	----	57.2	----	76	23	64	45	1	51	25	51	48	76	2.78	----	15	9,608	w.	50	w.	26	7	13	11	6.1	0.0	0.0
Trenton	190	159	183	29.72	29.92	----	59.0	----	82	10	68	42	1	50	30	53	49	77	2.78	−0.7	15	7,851	sw.	48	w.	26	2	13	16	7.1	0.0	0.0
Baltimore	123	100	215	29.79	29.92	−.07	63.2	−1.2	85	10	71	44	1	55	31	56	52	70	2.03	−1.5	15	7,102	sw.	43	nw.	27	5	13	13	6.8	0.0	0.0
Washington	112	62	85	29.80	29.92	−.08	64.0	+0.3	91	24	73	42	1	55	32	57	52	71	2.21	−1.6	12	4,595	nw.	32	nw.	26	4	13	14	6.8	0.0	0.0
Cape Henry	18	8	54	29.92	29.94	----	65.6	----	93	19	74	47	1	57	31	59	56	77	3.39	−0.6	12	8,864	sw.	46	w.	25	8	13	10	5.9	0.0	0.0
Lynchburg	681	153	188	29.21	29.94	−.06	66.2	−1.1	91	19	76	39	1	56	38	58	53	67	1.42	−2.6	13	5,739	w.	44	w.	15	7	17	7	5.7	0.0	0.0
Norfolk	91	170	205	29.86	29.95	−.05	66.7	+0.5	90	19	75	45	1	58	29	59	54	70	3.57	−0.5	11	9,691	sw.	74	w.	25	6	12	13	6.2	0.0	0.0
Richmond	144	11	52	29.79	29.94	−.05	66.2	−0.3	89	19	76	42	1	56	31	59	54	73	3.30	−0.6	15	5,728	sw.	40	nw.	25	6	15	10	6.0	0.0	0.0
Wytheville	2,304	49	55	27.61	29.94	−.05	60.9	−0.5	84	20	70	35	2	51	35	55	51	73	2.73	−1.2	14	5,513	w.	33	w.	15	4	19	8	6.3	0.0	0.0
South Atlantic States							71.7	+1.5										69	1.40	−2.4											5.0		
Asheville	2,253	70	84	27.65	29.96	−.03	64.3	+1.7	87	19	75	40	2	54	34	56	51	69	2.20	−1.4	14	6,126	nw.	32	nw.	11	11	13	7	5.1	0.0	0.0
Charlotte	779	55	62	29.14	29.96	−.03	70.6	+1.7	93	19	81	44	1	60	30	61	56	65	1.44	−2.5	7	3,411	sw.	29	nw.	25	7	13	11	6.0	0.0	0.0
Hatteras	11	11	50	29.95	29.96	−.05	69.2	+0.5	82	23	75	49	1	63	20	64	60	74	2.26	−1.9	12	10,887	sw.	48	n.	1	13	12	6	4.2	0.0	0.0
Raleigh	376	103	110	29.56	29.95	−.04	69.4	+0.9	93	19	80	43	1	59	29	61	57	69	2.69	−2.2	8	6,461	sw.	42	nw.	25	8	12	11	5.4	0.0	0.0
Wilmington	78	81	91	29.90	29.98	−.03	71.6	+0.8	89	20	81	49	1	63	24	65	62	77	0.91	−3.1	3	6,254	sw.	29	s.	29	12	14	5	4.9	0.0	0.0
Charleston	48	11	92	29.95	30.00	−.01	74.6	+1.9	95	26	83	55	1	67	28	67	64	74	0.71	−2.8	8	7,865	sw.	48	n.	29	14	13	4	4.3	0.0	0.0
Columbia, S. C	351	41	57	29.61	29.98	−.02	73.4	+1.5	96	20	84	49	17	63	30	62	56	62	1.60	−1.6	9	5,569	w.	35	w.	25	8	14	9	5.2	0.0	0.0
Due West	711	10	55	29.24	30.00	----	70.8	----	93	20	82	42	17	60	34	----	----	----	1.35	----	7	7,468	sw.	40	w.	11	8	17	6	5.3	0.0	0.0
Greenville, S. C	1,039	139	146	28.88	29.96	----	69.5	+2.3	88	20	79	45	17	60	30	61	56	67	1.57	----	8	7,587	sw.	45	w.	15	9	13	9	5.6	0.0	0.0
Augusta	182	62	77	29.78	29.97	−.02	74.2	+1.8	99	31	85	48	17	63	36	66	61	68	1.36	−1.9	6	4,535	nw.	34	ne.	29	8	17	6	5.1	0.0	0.0
Savannah	65	150	194	29.93	30.00	.00	75.2	+1.8	98	31	85	52	17	66	26	65	60	66	0.71	−2.3	6	9,359	w.	52	nw.	28	14	15	2	4.0	0.0	0.0
Jacksonville	43	209	245	29.97	30.02	+.02	76.7	+1.7	96	31	86	57	17	68	24	66	60	66	0.09	−4.2	2	8,364	sw.	30	w.	16	10	17	4	4.3	0.0	0.0
Florida Peninsula							79.6	+2.4										71	0.35	−3.9											3.6		
Key West	22	10	64	29.99	30.01	+.04	81.6	+2.5	89	14	87	71	3	76	15	73	70	72	T.	−3.4	0	7,479	se.	24	nw.	16	21	7	3	3.2	0.0	0.0
Miami	25	71	79	30.01	30.04	----	78.5	+2.1	91	14	85	57	17	72	26	71	68	71	0.68	−5.8	5	5,100	se.	24	e.	22	17	13	1	3.4	0.0	0.0
Tampa	35	79	87	29.99	30.02	+.03	78.8	+2.5	93	21	88	61	18	70	27	69	65	70	0.38	−2.5	3	4,436	w.	27	w.	14	13	15	3	3.7	0.0	0.0
Titusville	44	5	----	29.98	30.03	----	77.7	----	99	30	90	54	18	66	33	----	----	----	0.38	----	1	----	sw.	----	----	----	13	11	7	4.1	0.0	0.0
East Gulf States							73.9	+1.4										70	2.31	−1.2											5.1		
Atlanta	1,173	190	216	28.78	29.99	.00	71.1	+1.2	90	31	80	48	16	62	24	61	55	61	1.24	−1.8	7	8,486	w.	44	nw.	31	9	12	10	5.4	0.0	0.0
Macon	370	78	87	29.60	29.99	.00	73.6	+1.3	96	31	85	47	17	62	35	63	57	60	1.32	−1.6	5	4,863	sw.	26	nw.	11	11	10	10	5.3	0.0	0.0
Thomasville	273	49	58	29.72	30.01	+.01	76.4	+2.4	96	31	88	53	17	65	29	65	60	64	0.43	−3.6	4	3,871	sw.	24	sw.	4	10	10	11	5.3	0.0	0.0
Apalachicola	36	42	49	29.98	30.02	----	75.0	----	93	27	81	56	17	69	20	69	66	76	0.19	----	3	5,778	sw.	29	nw.	4	20	8	3	3.4	0.0	0.0
Pensacola	56	149	185	29.95	30.01	+.02	74.6	+0.7	88	27	80	56	14	70	26	70	67	80	0.77	−1.9	4	10,570	s.	32	sw.	11	11	10	10	5.2	0.0	0.0
Anniston	741	9	57	29.23	30.01	+.02	70.7	+2.3	91	29	83	40	17	59	38	----	----	----	2.18	−0.9	8	3,736	sw.	25	nw.	15	12	10	9	4.7	0.0	0.0
Birmingham	700	11	48	29.24	30.00	+.02	72.1	+1.0	91	29	82	47	16	62	31	63	59	68	3.53	+0.4	8	5,501	s.	28	nw.	15	13	10	8	4.7	0.0	0.0
Mobile	57	125	161	29.94	30.00	+.01	75.2	+0.8	92	26	82	56	14	68	27	69	66	76	1.49	−2.5	4	8,440	s.	35	n.	4	9	13	9	5.5	0.0	0.0
Montgomery	223	100	112	29.76	30.01	+.02	74.4	+1.0	94	29	84	52	17	64	28	65	59	64	2.95	−0.9	7	5,040	sw.	38	sw.	5	11	12	8	5.1	0.0	0.0
Corinth	469	6	----	----	----	----	72.4	----	91	29	82	48	12	62	35	----	----	----	5.02	----	10	----	s.	----	----	----	3	26	2	----	0.0	0.0
Meridian	375	87	95	29.58	29.97	−.01	73.4	+2.1	92	29	83	49	16	64	33	66	62	70	3.16	−0.8	6	5,069	sw.	27	sw.	25	9	13	9	5.6	0.0	0.0
Vicksburg	247	65	73	29.70	29.98	+.01	73.8	+0.9	92	9	82	55	12	66	25	66	62	71	5.21	+1.0	9	5,736	s.	26	s.	19	10	16	5	5.1	0.0	0.0
New Orleans	53	76	84	29.94	29.99	+.02	77.6	+2.2	92	31	84	59	13	71	23	70	67	75	3.14	−0.7	5	5,282	s.	25	ne.	13	10	14	7	5.3	0.0	0.0
West Gulf States							76.7	+3.3										74	2.67	−1.1											4.8		
Shreveport	249	77	93	29.65	29.91	−.04	75.8	+2.2	94	29	84	57	12	67	23	68	65	74	4.59	+0.4	10	5,626	s.	32	ne.	19	11	15	5	4.6	0.0	0.0
Bentonville	1,303	11	44	----	----	----	68.2	+1.8	89	28	79	41	16	57	33	----	----	----	4.38	----	10	4,983	s.	32	s.	8	13	11	7	----	0.0	0.0
Fort Smith	457	79	94	29.38	29.85	−.08	72.2	+2.6	96	28	82	47	16	63	27	65	61	71	6.41	+1.5	7	7,038	e.	37	nw.	24	8	13	10	5.4	0.0	0.0
Little Rock	357	136	144	29.52	29.89	−.06	71.8	+1.5	89	28	80	50	11	63	28	65	61	73	6.82	+1.7	8	8,430	s.	52	s.	3	10	10	11	5.7	0.0	0.0
Austin	605	136	148	29.24	29.87	----	79.2	+4.6	99	28	89	55	12	69	31	----	----	----	3.37	−1.0	5	7,514	se.	41	n.	24	12	14	5	4.9	0.0	0.0
Brownsville	57	53	61	29.76	29.82	----	81.6	+3.0	92	10	88	67	14	75	19	74	72	82	0.28	----	1	8,697	s.	35	s.	8	12	18	1	3.9	0.0	0.0
Corpus Christi	20	11	78	29.84	29.86	−.04	80.2	+4.0	90	30	85	65	13	75	20	74	72	82	0.32	−2.5	2	13,634	se.	49	se.	8	10	14	7	4.9	0.0	0.0
Dallas	512	220	227	29.31	29.85	----	76.1	----	103	28	85	51	12	67	28	----	----	----	3.23	----	4	11,853	se.	46	se.	8	14	13	4	4.3	0.0	0.0
Fort Worth	670	106	114	29.12	29.82	−.09	77.6	+5.3	107	28	88	54	11	68	32	66	61	63	0.44	−3.9	2	9,466	s.	30	se.	7	10	13	8	4.5	0.0	0.0
Galveston	54	106	114	29.87	29.93	−.01	77.9	+3.1	86	31	82	63	12	74	16	72	70	82	0.12	−3.1	3	11,362	s.	37	se.	5	10	13	4	4.4	0.0	0.0
Groesbeck	461	11	56	29.39	29.86	----	76.2	----	94	29	85	52	12	68	27	----	----	----	2.95	----	3	10,168	s.	44	s.	8	8	18	5	5.0	0.0	0.0
Houston	138	292	314	29.77	29.91	----	78.4	+2.9	95	25	86	56	12	70	23	----	----	----	0.34	−3.8	3	11,633	se.	44	se.	8	9	18	4	4.5	0.0	0.0
Palestine	510	64	72	29.36	29.88	−.05	75.8	+3.1	94	29	84	53	12	67	26	68	65	73	2.36	−2.5	5	7,610	s.	34	s.	8	6	18	7	5.5	0.0	0.0
Port Arthur	34	58	66	29.89	29.93	----	78.2	----	89	14	83	62	12	73	27	----	----	----	0.36	----	3	9,044	s.	39	ne.	12	11	13	7	4.7	0.0	0.0
San Antonio	693	119	132	29.12	29.83	−.07	80.4	+5.3	103	28	91	56	12	70	30	71	67	70	2.04	−0.9	3	6,841	s.	37	ne.	12	11	13	7	5.3	0.0	0.0
Taylor	583	55	63	29.29	29.90	−.01	78.4	+4.1	97	28	88	53	12	69	28	----	----	----	2.54	−1.5	3	8,686	s.	36	se.	12	10	17	4	4.7	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, May, 1927*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Ohio Valley and Tennessee							64.4	−0.5										71	4.92	+1.2										6.5		
Chattanooga	762	189	213	29.16	29.96	−.03	69.6	+0.8	89	31	79	45	17	60	31	61	55	63	2.60	−1.0	12	6,127	sw.	34	sw.	15	5	18	8	5.7	0.0	0.0
Knoxville	995	102	111	28.91	29.95	−.04	68.8	+1.6	90	21	79	46	17	58	35	60	56	71	2.92	−0.8	18	5,676	sw.	33	sw.	10	3	23	5	5.7	0.0	0.0
Memphis	399	76	97	29.49	29.91	−.06	71.8	+1.2	91	29	80	52	11	64	24	64	59	68	5.40	+1.1	11	6,682	sw.	38	sw.	9	8	13	10	5.7	0.0	0.0
Nashville	546	168	191	29.38	29.96	−.02	69.6	+1.4	87	24	78	45	2	61	32	61	56	68	3.63	+0.1	12	7,519	sw.	51	nw.	5	4	17	10	5.9	0.0	0.0
Lexington	989	193	230	28.88	29.93	−.06	63.4	−0.9	90	21	72	40	1	55	25	----	----	----	5.76	+2.2	20	10,721	sw.	48	se.	29	7	15	9	5.8	0.0	0.0
Louisville	525	188	234	29.35	29.93	−.05	64.4	−2.2	89	21	73	45	1	56	28	58	54	72	9.58	+5.9	21	8,260	w.	56	w.	7	7	17	6	6.9	0.0	0.0
Evansville	431	76	116	29.46	29.93	−.04	65.4	−1.3	86	21	74	46	16	57	29	60	56	74	7.80	+4.4	17	7,391	s.	36	s.	9	4	12	15	6.7	0.0	0.0
Indianapolis	822	194	230	29.02	29.90	−.07	61.2	−1.7	87	21	70	40	1	53	27	55	50	71	5.62	+1.7	19	9,681	s.	62	w.	18	5	13	13	7.1	0.0	0.0
Royal Center	736	11	55	29.09	29.89	------	57.9	------	85	21	67	33	1	49	30	----	----	----	6.98	------	17	9,052	w.	46	se.	29	4	10	17	6.9	0.0	0.0
Terre Haute	575	96	129	29.27	29.89	------	62.4	------	86	21	71	42	1	54	27	57	53	76	8.37	------	18	8,121	s.	40	nw.	14	2	18	11	6.7	0.0	0.0
Cincinnati	627	11	51	29.25	29.92	−.07	63.0	−0.1	90	21	73	38	1	53	33	56	53	74	4.67	+1.2	21	5,982	sw.	40	nw.	18	7	11	13	6.5	0.0	0.0
Columbus	822	179	222	29.05	29.91	−.07	60.4	−1.9	88	21	69	39	1	52	30	56	53	78	6.48	+2.8	19	8,069	w.	44	nw.	14	2	12	17	7.3	0.0	0.0
Dayton	899	137	173	28.96	29.91	------	61.5	−1.1	87	21	70	39	1	53	29	55	50	71	3.81	−0.1	17	8,030	sw.	42	sw.	10	5	15	11	6.5	0.0	0.0
Elkins	1,947	59	67	27.91	29.94	−.06	58.3	−0.9	87	9	68	32	2	48	36	53	49	74	4.13	+0.2	20	4,543	w.	30	nw.	3	1	13	17	7.6	0.0	0.0
Parkersburg	637	77	82	29.29	29.94	−.05	63.7	−0.1	91	21	73	40	1	54	35	56	50	66	2.76	−0.7	16	4,547	sw.	30	w.	10	8	11	12	6.4	0.0	0.0
Pittsburgh	842	353	410	29.01	29.91	−.08	60.1	−2.3	87	21	68	38	1	52	33	54	48	68	3.74	+0.4	18	8,697	sw.	38	sw.	26	3	9	19	7.3	0.0	0.0
Lower Lake Region							55.3	−2.1										73	3.71	−0.6										6.8		
Buffalo	767	247	280	29.05	29.88	−.09	53.0	−1.6	75	9	60	38	1	46	25	49	47	84	3.77	+0.8	18	11,759	sw.	54	sw.	10	4	11	16	7.0	0.0	0.0
Canton	448	10	61	29.40	29.87	------	52.3	−3.9	81	22	61	34	1	44	30	----	----	----	4.01	+1.2	19	6,605	sw.	34	e.	9	5	9	17	6.6	0.0	0.0
Oswego	335	76	91	----	29.89	−.08	51.8	−3.4	82	22	59	36	1	45	29	----	----	76	2.86	0.0	17	6,795	se.	28	se.	24	4	9	18	----	0.0	0.0
Rochester	523	86	102	29.33	29.90	−.07	55.1	−2.0	87	22	63	38	1	47	30	49	44	70	3.90	+1.0	20	6,152	w.	30	sw.	10	7	6	18	7.1	0.0	0.0
Syracuse	597	97	113	29.26	29.90	−.08	54.0	−3.3	87	22	62	37	3	46	30	----	----	----	3.34	0.0	18	4,986	nw.	29	s.	25	5	9	17	7.0	0.0	0.0
Erie	714	130	166	29.12	29.88	−.10	56.0	−0.8	85	9	63	36	1	49	29	51	47	73	3.73	+0.3	17	9,698	sw.	46	sw.	25	3	15	13	6.5	0.0	0.0
Cleveland	762	190	201	29.07	29.89	−.09	57.2	−0.7	87	9	64	39	15	51	27	52	47	70	3.44	+0.2	18	9,302	w.	44	sw.	10	5	8	18	7.0	0.0	0.0
Sandusky	629	56	67	29.20	29.88	−.10	57.8	−1.4	90	9	66	36	1	50	29	----	----	----	3.90	+0.6	17	7,385	sw.	35	sw.	10	4	9	18	7.2	0.0	0.0
Toledo	628	208	243	29.21	29.89	−.08	57.4	−2.0	87	22	65	40	15	50	27	52	48	74	2.60	−0.7	17	10,908	w.	54	sw.	10	7	13	11	6.1	0.0	0.0
Fort Wayne	856	113	124	28.96	29.88	------	57.8	−2.4	87	21	67	40	1	49	36	52	48	73	4.30	------	15	7,550	w.	40	w.	9	7	17	7	5.8	0.0	0.0
Detroit	730	218	258	29.10	29.89	−.08	56.4	−1.6	83	22	64	41	15	49	32	50	44	67	5.58	+2.3	18	8,321	w.	48	sw.	10	1	14	16	7.5	0.0	0.0
Upper Lake Region							50.8	−2.3										74	4.11	+0.7										7.2		
Alpena	609	13	92	29.23	29.89	−.08	48.2	−2.3	87	22	55	33	1	41	39	44	40	75	4.99	+1.7	17	8,838	se.	38	ne.	23	5	8	18	7.0	0.0	0.0
Escanaba	612	54	60	29.22	29.89	−.08	47.7	−1.9	74	22	54	34	20	42	25	43	39	74	3.42	0.0	17	8,473	n.	36	ne.	17	3	12	16	7.2	0.0	0.0
Grand Haven	632	54	89	29.19	29.87	−.09	52.4	−2.1	82	21	60	37	1	44	29	48	44	76	4.68	+1.3	16	9,185	e.	42	sw.	9	4	14	13	6.6	0.0	0.0
Grand Rapids	707	70	87	29.12	29.89	−.08	55.9	−2.1	88	21	65	37	1	46	35	49	43	68	3.81	+0.5	15	5,421	nw.	31	w.	9	1	12	18	7.7	0.0	0.0
Houghton	668	62	99	29.16	29.90	−.07	44.9	−4.6	64	12	52	31	20	38	29	----	----	----	5.86	+2.6	15	8,763	e.	61	ne.	9	7	7	17	7.0	T.	0.0
Lansing	878	11	62	28.94	29.88	------	55.3	−1.6	85	22	65	34	17	45	36	50	46	76	3.61	0.0	18	5,065	w.	27	s.	9	3	15	13	6.8	0.0	0.0
Ludington	637	60	66	29.17	29.87	------	50.0	------	78	21	58	35	27	42	28	46	44	82	4.89	------	19	8,339	s.	36	s.	9	2	14	15	6.9	0.0	0.0
Marquette	734	77	111	29.10	29.91	−.06	44.6	−4.4	67	17	51	31	20	38	25	41	37	78	5.45	+2.1	18	6,395	nw.	33	nw.	15	3	10	18	7.7	T.	0.0
Port Huron	638	70	120	29.18	29.87	−.10	53.5	−1.7	84	22	62	35	1	45	32	49	45	74	3.68	+0.4	19	8,248	ne.	37	nw.	25	1	19	11	6.9	T.	0.0
Saginaw	641	----	----	----	----	----	54.9	−2.0	86	9	66	34	1	44	36	----	----	----	5.74	------	20	----	w.	----	----	2	4	25	----	0.0	0.0
Sault Sainte Marie	614	11	52	29.22	29.92	−.03	47.9	−1.1	69	22	56	32	17	40	32	43	38	74	4.01	+0.8	16	6,485	se.	28	sw.	10	6	7	18	7.2	0.0	0.0
Chicago	673	7	131	29.15	29.88	−.08	56.8	−0.7	86	21	64	41	1	49	27	51	46	72	4.40	+1.0	17	8,805	sw.	53	sw.	9	6	6	19	7.2	0.0	0.0
Green Bay	617	109	141	29.20	29.86	−.09	52.4	−2.5	82	21	61	37	11	44	34	47	42	72	3.40	−0.2	16	9,258	ne.	38	s.	3	1	9	21	7.8	0.0	0.0
Milwaukee	681	125	221	29.14	29.87	−.09	52.6	−1.5	86	21	61	38	11	44	42	47	42	71	2.88	−0.5	17	11,264	w.	53	e.	20	4	9	18	7.3	0.0	0.0
Duluth	1,133	5	47	28.68	29.91	−.05	44.2	−3.1	74	1	52	33	18	37	33	40	35	76	3.27	−0.2	18	12,318	ne.	50	ne.	9	4	7	20	7.4	T.	0.0
North Dakota							48.4	−5.7										72	4.99	+2.5										7.5		
Moorhead	940	50	58	28.86	29.87	−.07	49.9	−5.2	75	16	58	31	14	41	33	46	41	73	3.63	+0.7	17	7,743	se.	49	se.	8	2	8	21	8.2	T.	0.0
Bismarck	1,674	8	57	28.10	29.88	−.04	49.1	−5.4	82	16	58	29	11	40	41	44	39	72	7.04	+4.5	14	10,270	e.	46	ne.	8	6	10	15	6.4	0.0	0.0
Devils Lake	1,478	11	44	28.33	29.91	−.03	47.2	−5.5	77	16	55	31	6	39	30	43	38	74	4.60	+2.4	17	10,438	ne.	52	ne.	9	3	6	22	7.7	T.	0.0
Ellendale	1,457	10	56	28.30	29.86	------	48.8	------	75	16	57	29	5	40	36	----	----	----	5.89	------	17	13,746	nw.	55	nw.	2	1	10	20	8.0	T.	0.0
Grand Forks	833	12	67	----	----	----	49.3	------	75	16	57	33	14	41	32	45	----	----	5.05	------	14	----	n.	38	ne.	9	7	8	16	----	0.0	0.0
Williston	1,878	41	48	27.92	29.91	−.02	47.4	−6.6	80	16	56	25	10	39	34	43	37	71	4.69	+2.4	20	9,726	e.	44	se.	1	5	8	18	7.1	11.2	0.0
Upper Mississippi Valley							59.2	−2.3										73	6.28	+2.1										7.0		
Minneapolis	918	102	208	28.86	29.84	------	53.8	−3.9	82	21	62	36	14	46	35	----	----	----	3.22	−0.7	17	10,172	nw.	44	nw.	2	2	9	20	8.0	T.	0.0
St. Paul	837	236	261	28.94	29.84	−.10	53.5	−4.4	81	21	62	35	14	45	33	----	----	----	2.59	−1.0	16	11,025	nw.	60	e.	8	4	16	11	6.7	T.	0.0
La Crosse	714	11	48	29.08	29.85	−.09	56.2	−3.1	85	21	65	34	12	47	35	50	45	71	4.59	+0.8	19	4,000	w.	22	sw.	3	2	11	18	7.8	0.0	0.0
Madison	974	70	78	28.83	29.88	−.08	54.3	−3.3	83	21	62	37	11	46	29	49	44	73	6.85	+3.2	13	7,617	nw.	36	s.	9	4	10	17	7.5	T.	0.0
Wausau	1,247	4	----	28.54	29.87	------	51.6	------	80	21	61	33	12	42	38	----	----	----	3.28	------	16	----	w.	----	----	4	5	22	7.9	0.1	0.0
Charles City	1,015	10	49	28.79	29.86	−.08	56.0	−1.8	83	21	65	36	12	47	33	51	46	73	6.75	+1.8	11	6,523	se.	36	sw.	3	7	14	10	6.1	0.0	0.0
Davenport	606	71	79	29.20	29.86	−.09	59.3	−2.0	84	21	68	42	15	51	27	54	51	78	5.63	+1.4	13	6,567	e.	38	e.	27	4	10	17	7.2	0.0	0.0
Des Moines	861	84	97	28.94	29.84	−.09	60.2	−1.1	87	23	70	38	12	51	32	54	49	70	3.99	−0.6	12	6,606	nw.	37	sw.	9	5	11	15	6.8	0.0	0.0
Dubuque	700	81	96	29.09	29.84	−.11	56.8	−3.5	86	21	65	40	16	49	29	51	46	70	7.91	+3.6	15	5,551	nw.	29	s.	9	5	7	19	7.5	0.0	0.0
Keokuk	614	64	78	29.20	29.86	−.08	61.2	−2.6	85	23	70	40	12	52	28	56	52	74	4.55	+0.3	12	6,104	s.	35	sw.	23	3	15	13	6.7	0.0	0.0
Cairo	358	87	93	29.53	29.90	−.06	68.0	−0.4	85	21	76	49	12	60	26	62	59	77	10.18	+6.4	13	6,964	s.	40	nw.	18	4	11	16	6.7	0.0	0.0
Peoria	609	11	45	29.22	29.88	−.08	60.0	−1.7	85	21	69	38	16	51	29	54	50	74	9.22	+5.0	12	5,431	nw.	30	nw.	23	2	15	14	6.9	0.0	0.0
Springfield, Ill	636	10	91	29.20	29.87	−.08	61.8	−1.4	86	21	71	43	16	53	29	56	52	74	7.01	+2.5	14	7,118	s.	42	n.	18	4	12	15	6.7	0.0	0.0
Hannibal	534	74	109	29.29	29.86	−.08	62.6	−1.0	88	23	71	39	12	54	33	----	----	----	6.25	+1.2	15	6,815	w.	48	sw.	23	6	9	16	6.4	0.0	0.0
St. Louis	568	265	303	29.28	29.88	−.07	64.5	−2.4	85	8	72	44	12	57	27	58	54	72	9.21	+5.0	15	10,525	s.	75	w.	9	10	7	14	6.1	0.0	0.0
Missouri Valley							60.4	−1.1										68	4.25	0.0										5.7		
Columbia, Mo	784	11	84	29.03	29.86	−.08	63.2	−1.1	88	23	72	39	12	54	30	----	----	----	6.68	+1.8	16	6,320	se.	32	sw.	23	6	12	13	6.1	0.0	0.0
Kansas City	963	161	181	28.82	29.85	−.07	64.3	−0.5	89	23	73	41	11	56	31	57	52	67	5.46	+0.4	11	9,142	s.	55	nw.	13	9	15	7	5.1	0.0	0.0
St. Joseph	967	11	49	28.81	29.84	------	64.2	------	88	23	74	41	11	54	30	56	51	67	2.37	------	13	7,490	nw.	55	nw.	24	15	12	4	4.0	0.0	0.0
Springfield, Mo	1,324	98	104	28.45	29.83	−.10	65.6	+1.1	87	28	75	40	11	56	30	59	55	72	5.85	+0.3	14	8,933	s.	48	sw.	23	15	12	4	3.5	0.0	0.0
Iola	984	11	50	28.80	29.82	−.10	65.6	+0.4	93	23	76	38	11	55	33	----	----	----	4.14	−1.1	8	5,483	s.	33	s.	23	7	12	12	6.1	0.0	0.0
Topeka	987	92	107	----	----	----	64.4	+0.1	88	27	74	40	11	55	31	----	----	----	2.69	−2.2	9	8,476	nw.	38	sw.	20	12	12	7	4.5	0.0	0.0
Lincoln	1,189	11	84	28.59	29.83	−.08	61.2	−0.5	89	17	72	36	11	51	33	53	47	65	1.57	−2.7	9	9,676	n.	48	w.	17	7	8	16	6.6	0.0	0.0
Omaha	1,105	115	122	28.67	29.84	−.08	61.6	−0.8	91	17	70	39	10	52	29	53	47	64	1.36	−3.1	11	7,604	nw.	36	nw.	14	8	11	12	6.1	0.0	0.0
Valentine	2,598	47	54	27.15	29.84	−.06	55.2	−1.0	86	16	66	31	11	44	39	48	41	65	4.29	+1.0	18	9,064	nw.	51	nw.	9	6	14	11	6.0	0.4	0.0
Sioux City	1,135	94	164	28.65	29.85	−.07	58.2	−2.2	86	17	67	37	5	50	27	52	47	70	5.27	+0.9	13	11,344	nw.	52	w.	3	3	15	13	6.8	0.0	0.0
Huron	1,306	59	74	28.47	29.86	−.06	53.5	−2.9	81	16	63	34	5	44	36	48	42	70	3.92	+1.0	14	8,943	nw.	48	nw.	3	3	11	17	7.0	0.0	0.0
Pierre	1,572	70	75	----	29.85	−.06	54.8	−3.2	86	16	64	33	5	46	36	----	----	71	5.15	+3.0	15	10,095	e.	56	nw.	3	6	10	15	----	0.0	0.0
Yankton	1,233	49	57	28.51	29.82	−.10	57.2	−2.2	87	21	66	34	5	48	34	----	----	----	4.62	+0.7	9	7,216	nw.	42	nw.	3	7	9	15	6.8	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, May, 1927*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								0–10	*In.*	*In.*
Northern Slope							49.8	−3.0										64	3.72	+1.3										6.6		
Billings	3,140	5					50.0		87	16	63	24	3	37	46				3.70		13		nw.				5	6	20			
Havre	2,505	11	44	27.29	29.92	−.01	48.6	−4.8	81	15	58	28	3	40	38	43	38	71	7.09	+5.0	21	6,094	e.	36	w.	12	4	9	18	7.4	T.	0.0
Helena	4,110	87	112	25.74	29.95	+.02	45.2	−6.4	81	16	54	26	3	37	33	39	33	67	6.69	+4.7	17	6,874	sw.	41	sw.	17	0	5	26	8.7	13.9	0.0
Kalispell	2,973	48	56	26.88	29.94	+.06	48.0	−3.4	79	15	57	30	3	39	35	40	32	60	1.54	−0.5	9	5,208	nw.	40	sw.	17	3	12	16	6.7	0.4	0.0
Miles City	2,371	48	55	27.39	29.94	+.03	52.0	−4.7	82	16	61	24	10	43	36	46	41	73	4.74	+2.8	19	6,500	ne.	48	nw.	17	4	11	16	6.6	7.0	0.0
Rapid City	3,259	50	58	26.50	29.90	.00	50.9	−3.1	83	16	60	31	10	42	34	44	38	64	5.53	+2.6	18	7,578	nw.	41	nw.	9	5	12	14	6.5	0.1	0.0
Cheyenne	6,088	84	101	23.89	29.78	−.07	51.0	+0.7	81	17	64	21	9	38	37	41	31	53	2.01	−0.4	9	12,596	w.	64	w.	17	6	20	5	5.5	8.0	0.0
Lander	5,372	60	68	24.56	29.87	−.01	50.0	−1.2	82	16	62	27	9	38	37	41	32	59	1.50	−1.4	7	5,858	w.	62	sw.	19	6	17	8	5.7	2.6	0.0
Sheridan	3,790	10	47	26.00	29.88		49.6		83	17	61	19	10	38	39	43	36	67	3.98		15	5,449	nw.	36	nw.	17	2	19	10	6.4	4.4	0.0
Yellowstone Park	6,241	11	48	23.80	29.91	.00	41.0	−6.4	74	16	50	21	3	32	38	36	31	71	2.96	+1.0	19	6,205	s.	54	s.	17	0	11	20	8.0	13.8	0.0
North Platte	2,821	11	51	26.94	29.82	−.06	61.4	+2.7	97	17	74	35	11	48	41	51	43	60	1.40	−1.7	11	7,412	se.	52	se.	8	19	5	7	4.2	0.0	0.0
Middle Slope							64.9	+2.4										58	1.44	−2.4									4.6		
Denver	5,292	106	113	24.60	29.76	−.08	59.6	+3.4	89	17	72	33	8	47	33	46	33	45	1.40	−1.1	1	6,432	nw.	40	so.	19	15	14	2	3.7	T.	0.0
Pueblo	4,685	80	86	25.14	29.73	−.10	64.0	+4.8	92	17	79	34	10	49	40	47	30	37	0.95	−0.7	1	6,602	e.	44	nw.	8	18	11	2	3.2	0.0	0.0
Concordia	1,392	50	58	28.36	29.82	−.09	63.1	−0.1	88	20	74	37	11	53	33	55	49	64	1.51	−3.2	4	7,653	s.	38	s.	8	9	10	12	5.5	0.0	0.0
Dodge City	2,509	11	51	27.26	29.81	−.06	66.0	+2.5	98	17	79	34	10	53	43	55	48	59	0.74	−2.6	5	8,779	ne.	50	s.	8	20	8	3	3.1	0.0	0.0
Wichita	1,358	139	158	28.40	29.81	−.09	65.8	+0.7	93	27	75	40	11	56	33	58	53	68	2.13	−2.8	10	11,011	s.	52	s.	8	7	16	8	5.5	0.0	0.0
Broken Arrow	765	11	56	29.02	29.84		69.4		90	28	79	46	11	60	27				2.87		11	11,234	s.	57	n.	6	7	7	17	6.4	0.0	0.0
Oklahoma City	1,214	10	47	28.56	29.80	−.09	71.1	+3.4	96	27	81	46	10	61	32	62	57	66	1.94	−3.8	4	9,054	s.	39	s.	23	10	17	4	4.7	0.0	0.0
Southern Slope							76.2	+5.6										43	0.26	−2.4									3.1		
Abilene	1,738	10	52	28.02	29.77	−.10	78.6	+6.6	106	28	91	53	10	66	33	63	53	51	0.78	−2.9	2	9,999	s.	39	sw.	8	17	11	3	3.5	0.0	0.0
Amarillo	3,676	10	49	26.13	29.77	−.07	71.0	+6.9	100	17	86	40	10	55	41	54	39	41	0.07	−3.6	1	7,433	sw.	46	sw.	8	21	7	3	2.7	0.0	0.0
Del Rio	944	64	71	28.80	29.76	−.09	82.8	+5.8	108	28	94	62	14	72	34	69	61	55	0.17	−2.2	1	8,126	se.	32	e.	10	14	11	6	4.4	0.0	0.0
Roswell	3,566	75	85	26.22	29.73	−.09	72.6	+3.2	97	19	89	46	25	56	46	51	27	25	0.04	−1.1	2	7,698	sw.	50	sw.	8	26	5	0	1.9	0.0	0.0
Southern Plateau							67.2	+1.9										30	0.06	−0.3									1.6		
El Paso	3,778	152	175	26.08	29.76	−.02	75.6	+4.1	96	25	90	46	8	62	39	51	25	19	0.00	−0.4	0	10,091	w.	57	nw.	7	26	5	0	1.6	0.0	0.0
Santa Fe	7,013	38	53	23.19	29.72	−.09	58.6	+2.9	82	16	73	30	9	44	36	40	19	25	0.16	−1.0	1	5,745	sw.	31	sw.	28	24	5	2	2.4	T.	0.0
Flagstaff	6,907	10	59	23.31	29.80	+.02	51.0	+0.3	80	14	67	23	23	35	45	38		44	0.39		2	8,269	sw.	40	sw.	21	23	5	3		T.	0.0
Phoenix	1,108	10	82	28.65	29.78	.00	76.0	+1.0	107	14	93	49	9	60	43	54	33	26	0.17	+0.1	2	4,354	w.	25	sw.	7	22	9	0	1.9	0.0	0.0
Yuma	141	9	54	29.66	29.80	+.01	77.8	+1.6	113	14	95	52	8	60	47	57	40	34	0.00	0.0	0	4,443	w.	25	w.	6	29	2	0	0.6	0.0	0.0
Independence	3,957	5	25	25.88	29.86	+.02	64.5	+1.5	96	15	81	28	22	48	43	45			0.00	−0.2	0		nw.				24	5	2		0.0	0.0
Middle Plateau							55.3	−0.6										42	1.14	0.0									3.8		
Reno	4,532	74	81	25.44	29.94	+.03	53.4	−0.2	92	15	67	28	20	39	42	41	28	45	0.25	−0.5	4	6,599	w.	42	w.	1	17	11	3	3.4	0.7	0.0
Tonopah	6,090	12	20	24.00	29.83		55.0		87	16	66	26	21	44	30	41	24	31	T.		0		nw.									
Winnemucca	4,344	18	56	25.58	29.96	+.05	52.4	−1.5	93	15	67	26	29	38	49	42	32	56	0.90	−0.1	7	5,466	w.	34	w.	1	11	18	2	4.4	4.0	0.0
Modena	5,473	10	43	24.53	29.82	.00	53.6	+0.1	87	16	70	26	22	37	44	39	22	36	0.23	−0.6	3	9,278	sw.	56	sw.	6	19	9	3	2.8	T.	0.0
Salt Lake City	4,360	163	203	25.54	29.88	+.02	55.6	−1.8	93	16	66	33	8	45	32	44	32	47	3.78	+1.8	9	5,686	nw.	36	sw.	6	11	7	13	5.7	2.3	0.0
Grand Junction	4,602	60	68	25.25	29.78	−.05	61.4	+0.3	92	16	76	33	9	47	36	45	27	34	0.54	−0.4	3	5,753	se.	42	s.	7	21	7	3	2.6	T.	0.0
Northern Plateau							53.4	−2.8										56	1.43	−0.3									7.0		
Baker	3,471	48	53	26.43	30.01	+.05	48.2	−3.5	83	14	59	27	2	37	39	41	34	61	1.09	−0.6	12	4,761	nw.	30	sw.	16	4	10	17	7.2	T.	0.0
Boise	2,739	78	86	27.12	29.97	+.03	54.4	−2.7	94	16	66	33	20	43	37	45	35	56	1.72	+0.4	9	4,475	nw.	32	w.	1	6	7	18	6.9	T.	0.0
Lewiston	757	40	48	29.17	29.98	+.02	56.4	−3.1	88	14	67	35	5	45	40				1.04	−0.6	13	2,937	e.	45	w.	17	5	4	22	7.4	0.0	0.0
Pocatello	4,477	60	68	25.39	29.88	−.01	51.8	−2.0	90	16	63	32	3	41	37	42	31	51	2.54	+0.3	12	6,956	sw.	36	sw.	17	4	12	15	6.5	0.5	0.0
Spokane	1,929	101	110	27.94	29.99	+.03	52.6	−2.9	80	14	62	33	5	43	34	44	36	58	1.24	−0.2	14	5,365	s.	34	sw.	17	2	7	22	7.7	0.0	0.0
Walla Walla	991	57	65	28.94	30.01	+.05	56.9	−2.7	87	15	66	38	6	47	34	47	38	53	0.94	−0.9	9	4,418	s.	29	w.	17	6	16	9	6.0	0.0	0.0
North Pacific Coast Region							52.6	−1.0										75	2.36	+0.1									7.3		
North Head	211	11	56	29.88	30.11	+.08	49.6	−1.3	62	14	53	42	1	46	11	47	45	85	2.73	+0.3	16	12,335	n.	70	sw.	1	1	4	26	8.8	0.0	0.0
Port Angeles	29	8	53	30.07	30.10		49.7		66	31	57	35	5	42	26				0.70	−0.6	6	5,046	sw.	34	nw.	17	6	9	16	7.0	0.0	0.0
Seattle	125	215	250	29.94	30.07	+.06	52.4	−2.1	74	14	59	42	5	46	24	47	43	73	1.81	0.0	13	7,299	s	44	s.	1	4	9	18	7.3	0.0	0.0
Tacoma	194	172	201	29.89	30.10	+.08	53.3	−0.8	75	14	60	39	5	46	26				2.57	+0.4	12	6,891	s.	44	s.	1	4	13	14	7.1	0.0	0.0
Tatoosh Island	86	9	53	29.97	30.07	+.06	49.1	−0.5	61	14	52	41	1	46	12	47	45	87	4.69	+0.6	14	8,695	w.	56	w.	17	6	10	15	6.9	0.0	0.0
Yakima	1,071	5					56.2		87	15	71	31	11	42	41				0.32		4		nw.				4	13	14	6.6	0.0	0.0
Medford	1,425	4					55.2		90	14	69	30	2	42	42	47	41	69	0.92		12		nw.				7	7	17		0.0	0.0
Portland, Oreg	153	68	106	29.94	30.10	+.07	55.4	−1.5	86	14	63	43	1	48	31	49	44	69	2.24	0.0	16	4,453	nw.	30	sw.	1	1	6	24	8.5	0.0	0.0
Roseburg	510	9	57	29.56	30.11	+.08	56.0	0.0	91	14	68	37	2	44	40	49	43	68	1.80	−0.2	10	2,769	nw.	31	sw.	16	7	8	16	6.2	0.0	0.0
Middle Pacific Coast Region							59.7	−0.2										67	0.67	−0.6									3.3		
Eureka	62	73	89	30.09	30.16	+.11	51.2	−0.8	60	13	56	40	2	47	16	49	47	87	1.68	−0.9	8	5,985	n.	27	sw.	16	5	14	12	6.4	0.0	0.0
Red Bluff	332	50	56	29.62	29.97	+.02	65.6	−0.7	103	15	79	41	28	52	37	53	43	50	1.30	0.0	4	4,688	nw.	26	n.	20	19	12	0	2.7	0.0	0.0
Sacramento	69	106	117	29.91	29.98	+.04	63.8	+0.5	99	15	77	44	28	50	39	53	45	58	0.21	−0.8	3	6,163	s.	30	sw.	26	23	8	0	1.7	0.0	0.0
San Francisco	155	208	243	29.86	30.03	+.04	58.2	+1.4	88	24	66	48	9	50	36	51	46	72	0.10	−0.7	3	7,596	w.	36	w.	19	19	11	1	2.9	0.0	0.0
San Jose	141	12	110	29.89	30.04		59.5	−1.2	97	13	74	40	30	46	47				0.08	−0.4	3	5,454	nw.	30	nw.	20	21	7	3	2.7	0.0	0.0
South Pacific Coast Region							63.0	+0.9										64	0.09	−0.5									2.9		
Fresno	327	89	98	29.62	29.97	+.05	67.1	0.0	102	15	82	44	21	52	39	52	39	45	0.18	−0.4	1	7,363	nw.	36	nw.	27	27	3	1	1.4	0.0	0.0
Los Angeles	338	159	191	29.59	29.95	.00	63.8	+1.6	98	13	73	50	7	55	31	55	49	65	T.	−0.5	0	4,008	sw.	22	sw.	21	16	13	2	3.4	0.0	0.0
San Diego	87	62	70	29.86	29.95	.00	61.4	+0.6	88	13	67	51	22	56	27	56	53	78	0.12	−0.9	2	5,265	w.	25	w.	7	12	12	7	4.8	0.0	0.0
San Luis Obispo	201	32	40	29.81	30.03	+.03	59.6	+1.4	100	13	72	38	8	47	49	50	44	66	0.05	−0.8	1	4,447	nw.	25	w.	20	23	8	0	1.9	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.90	29.99		78.4	−0.2	90	2	83	71	21	74	15				10.36	+5.6	18	9,687	e.	37	e.	22	4	10	17	7.3	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	29.72	29.84	.00	80.2	−0.5	91	14	86	72	2	74	17	76	75		9.06	+1.1	22	4,120	nw.	25	n.	1	0	7	24	8.2	0.0	0.0
Colon	38	7	97	29.81	29.84	.00	81.0	+0.3	89	2	86	74	2	76	15	77	76		14.11	+1.7	27	5,258	w.	23	nw.	26	0	3	28	9.3	0.0	0.0
Alaska																																
Juneau	80	11	54	[1] 29.92	[1] 30.01		46.6		69	19	54	31	5	39	29	42	37	74	3.89		19	5,234	s.	25	e.	1	6	7	18	7.3	0.0	0.0
Hawaiian Islands																																
Honolulu	38	86	100	[1] 30.02	[1] 30.06		75.4		82	23	80	67	12	71	13	68	65	70	3.58	+1.8	21	7,740	e.	36	e.	15	3	20	8	5.9	0.0	0.0

[1] Pressure not corrected to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, May, 1927*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max.+ mean min.÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*In.*	*In.*	*In.*
St. Johns, N. F.	125												
Sydney, C. B. I.	48	29.85	29.90	−0.07	44.5	−0.7	54.2	34.9	69	31	2.76	−1.01	6.0
Halifax, N. S.	88	29.66	29.76	−.22	47.1	−1.3	55.8	38.5	74	28	3.74	−0.52	0.0
Yarmouth, N. S.	65	29.77	29.84	−.14	46.7	−0.9	54.3	39.1	64	30	3.88	+0.31	0.0
Charlottetown, P. E. I.	38	29.83	29.87	−.09	45.7	−1.2	53.4	38.1	65	31	2.65	−0.26	0.0
Chatham, N. B.	28	29.79	29.82	−.13	45.8	−2.7	55.3	36.3	70	27	3.56	+0.35	0.0
Father Point, Que.	20	29.88	29.90	−.03	42.5	−1.5	49.0	36.0	65	32	4.90	+2.32	0.0
Quebec, Que.	296	29.58	29.90	−.04	48.6	−1.3	56.1	41.1	73	31	3.95	+0.87	0.0
Montreal, Que.	187	29.66	29.87	−.07	52.7	−2.0	60.4	45.0	76	37	4.79	+1.84	0.0
Stonecliffe, Ont.	489												
Ottawa, Ont.	236	29.62	29.88	−.06	53.7	−1.2	63.2	44.2	85	32	5.58	+2.99	0.0
Kingston, Ont.	285	29.57	29.88	−.08	51.4	−1.5	57.7	45.1	74	35	3.90	+1.22	0.0
Toronto, Ont.	379	29.47	29.88	−.10	52.7	−0.5	60.7	44.8	75	35	3.20	+0.16	0.0
Cochrane, Ont.	930												
White River, Ont.	1,244	28.58	29.91	−.04	43.7	−2.0	55.1	32.4	68	21	3.79	+1.84	0.0
Port Stanley, Ont.	592												
Southampton, Ont.	656	29.17	29.89	−.07	49.0	−1.7	57.3	40.8	76	29	3.82	+1.38	0.0
Parry Sound, Ont.	688	29.18	29.88	−.07	49.7	−1.4	58.5	41.0	73	29	5.09	+2.16	0.0
Port Arthur, Ont.	644	29.24	29.95	−.01	44.0	−1.9	50.9	37.1	63	29	4.50	+2.35	0.0
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.14	29.97	+.01	45.6	−2.8	53.1	38.1	74	30	5.43	+3.98	1.7
Le Pas, Man.	860				47.5		54.4	30.6	69	19	0.79		T.
Qu'Appelle, Sask.	2,115	27.68	29.93	−.01	44.8	−5.0	53.1	36.5	71	20	3.69	+2.04	0.0
Medicine Hat, Alb.	2,144	27.61	29.87	−.02	49.6	−4.5	57.7	41.5	80	26	5.30	+3.99	0.0
Moose Jaw, Sask.	1,759				47.6		56.5	38.7	76	24	4.14		0.0
Swift Current, Sask.	2,392	27.36	29.89	−.03	47.4	−3.3	56.8	38.1	80	25	6.58	+4.82	7.3
Calgary, Alb.	3,428	26.43	30.02	+.14	44.8	−4.2	54.9	34.8	77	24	2.73	+0.96	0.0
Banff, Alb.	4,521	25.37	29.96	+.08	41.8	−5.2	51.0	32.6	67	25	2.53	+0.49	8.2
Edmonton, Alb.	2,150	27.68	29.97	+.09	46.3	−4.5	56.7	35.9	74	22	2.03	+0.48	9.3
Prince Albert, Sask.	1,450	28.47	30.06	+.11	47.4	−0.2	58.2	36.6	71	26	1.09	−0.17	0.0
Battleford, Sask.	1,592	28.26	30.01	+.09	47.7	−3.3	58.2	37.2	74	27	1.19	−0.43	0.0
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.81	30.07	+.07	51.4	−1.1	57.7	45.2	68	40	0.77	−0.71	0.0
Barkerville, B. C.	4,180												
Triangle Island, B. C.	680												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.98	30.14	+.08	69.3	−0.1	76.7	61.9	84	57	4.06	−0.60	0.0

LATE REPORTS, APRIL, 1927

Sydney, C. B. I.	48	29.89	29.94	+.05	35.7	+0.7	45.2	26.2	69	10	3.89	+0.04	13.5
Halifax, N. S.	88	29.70	29.81	−.15	37.3	−0.5	45.7	29.0	71	19	4.90	+0.72	2.6
Yarmouth, N. S.	65	29.85	29.92	−.04	38.6	−0.3	45.8	31.4	68	20	2.84	−0.98	1.2
Charlottetown, P. E. I.	38												
Chatham, N. B.	28	29.83	29.86	−.04	36.4	+0.9	47.7	25.2	73	7	3.20	+0.57	11.6
Cochrane, Ont.	930				30.5		42.8	18.2	68	−2	0.70		3.0
Kamloops, B. C.	1,262	28.65	29.95	+.02	47.4	−1.5	59.8	35.0	73	20	0.05	−0.34	T.
Barkerville, B. C.	4,180	25.55	29.90	+.04	31.2	−1.9	40.7	21.7	52	−8	4.99	+3.17	39.4

Chart I. Tracks of Centers of Anticyclones, May, 1927. (Inset) Departure of Monthly Mean Pressure from Normal
(Plotted by Wilfred P. Day)

Chart I. Tracks of Centers of Anticyclones, May, 1927. (Inset) Departure of Monthly Mean Pressure from Normal
(Plotted by Wilfred P. Day)

Chart II. Tracks of Centers of Cyclones, May, 1927. (Inset) **Change in Mean Pressure from Preceding Month**

(Plotted by Wilfred P. Day)

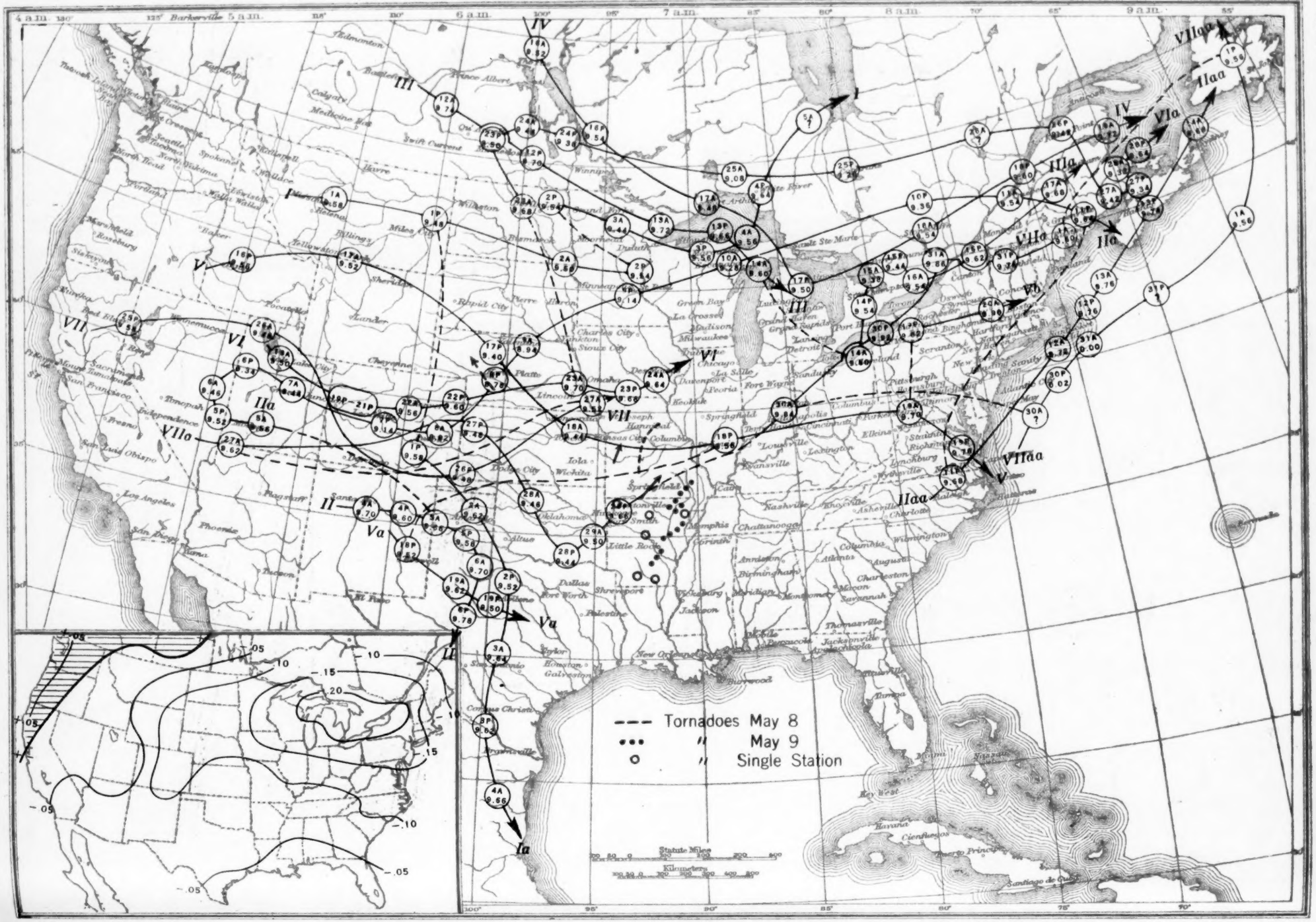


Chart III. Departure (°F.) of the Mean Temperature from the Normal, May, 1927

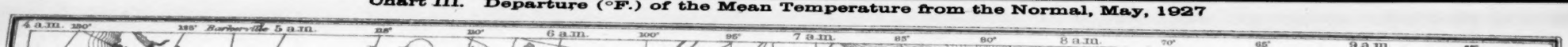


Chart III. Departure (°F.) of the Mean Temperature from the Normal, May, 1927

Shaded portions show excess (+).
Unshaded portions show deficiency (—).
Lines show amount of excess or deficiency.
Statute Miles
Kilometers

Chart IV. Total Precipitation, Inches, May, 1927. (Inset) Departure of Precipitation from Normal

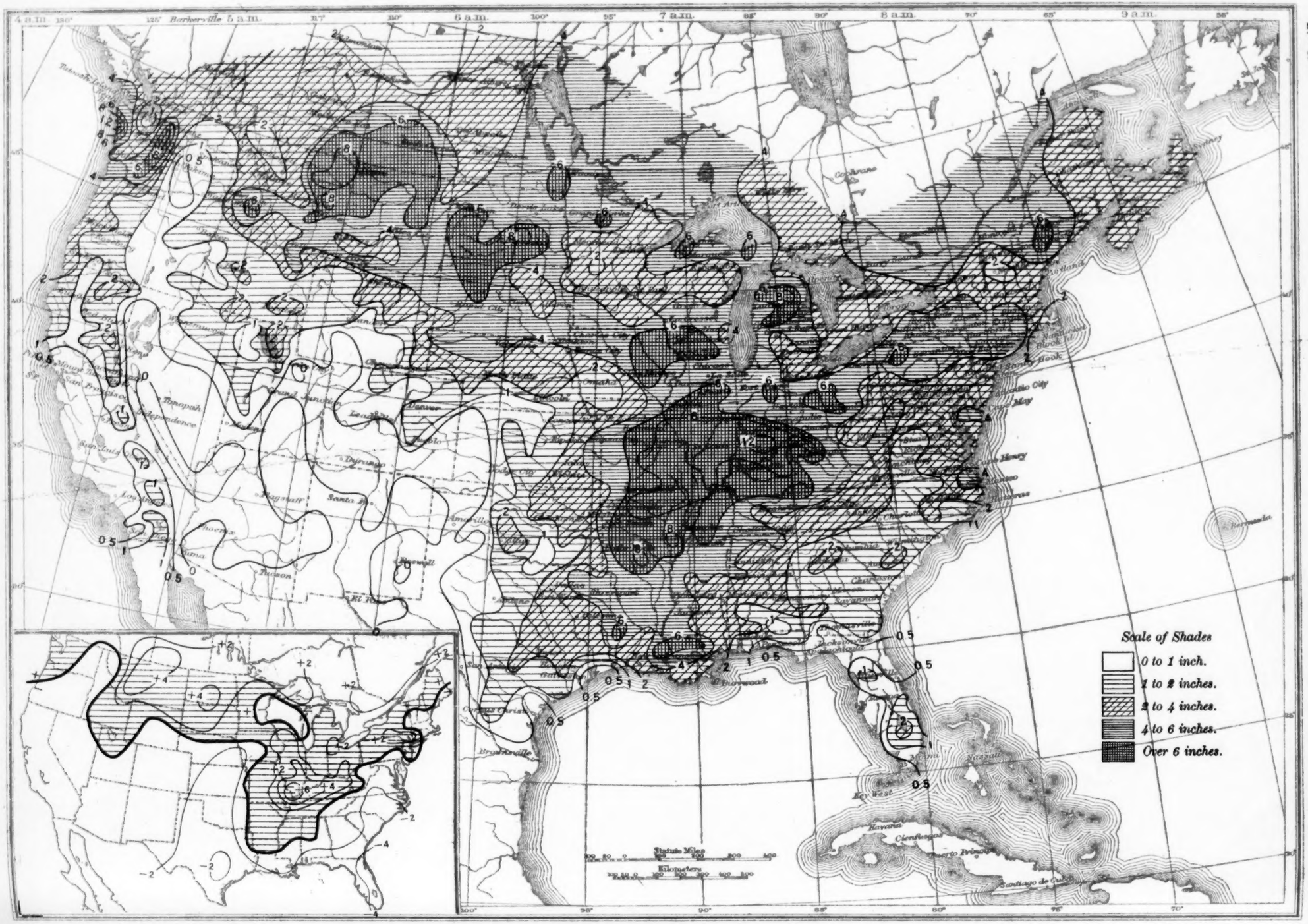


Chart V. Percentage of Clear Sky between Sunrise and Sunset, May, 1927

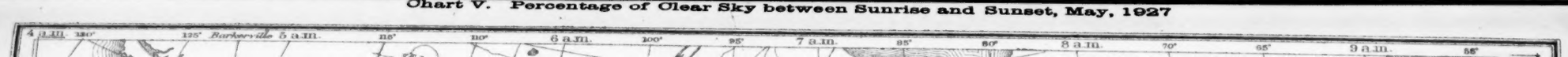


Chart V. Percentage of Clear Sky between Sunrise and Sunset, May, 1927

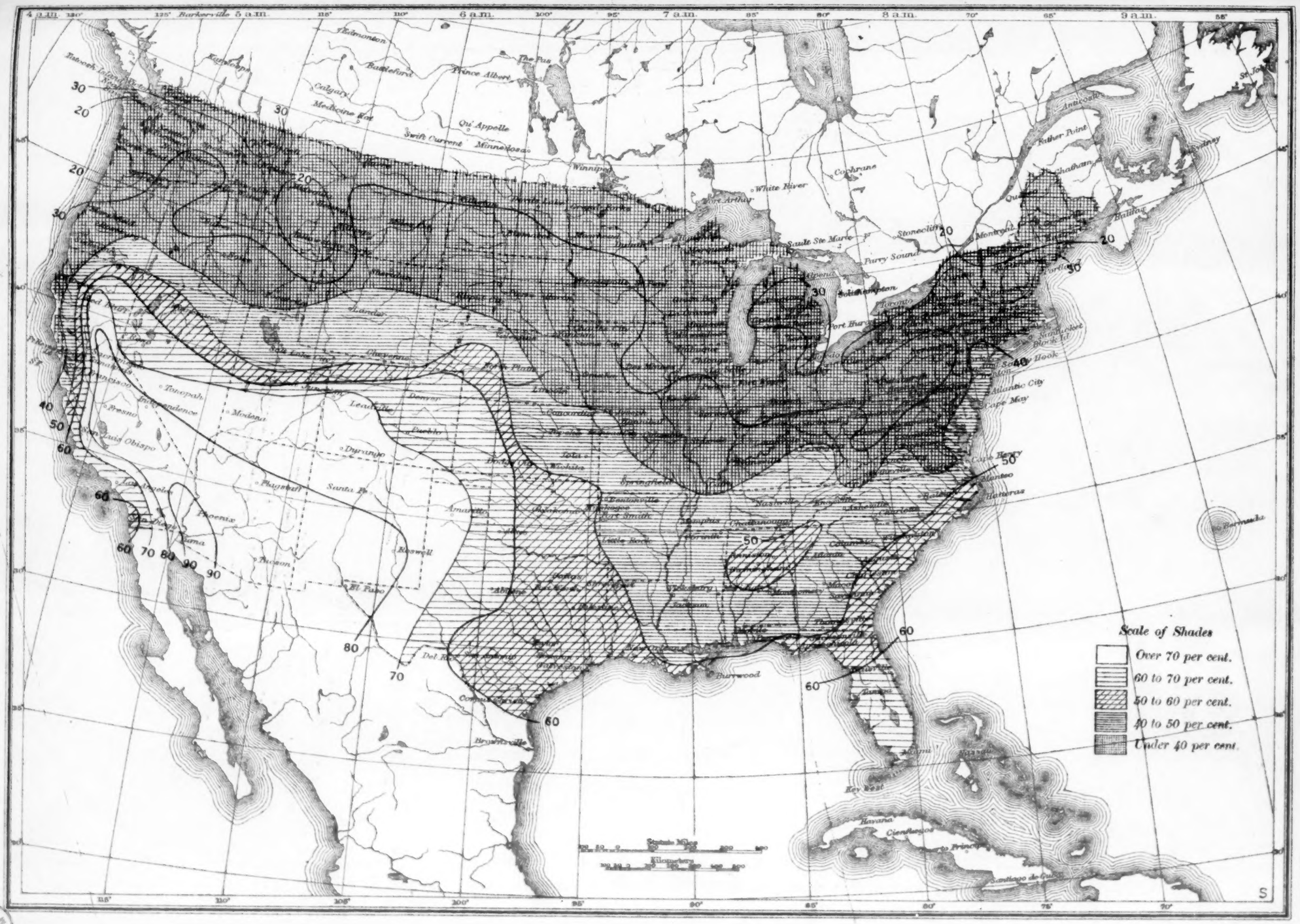


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, May, 1927

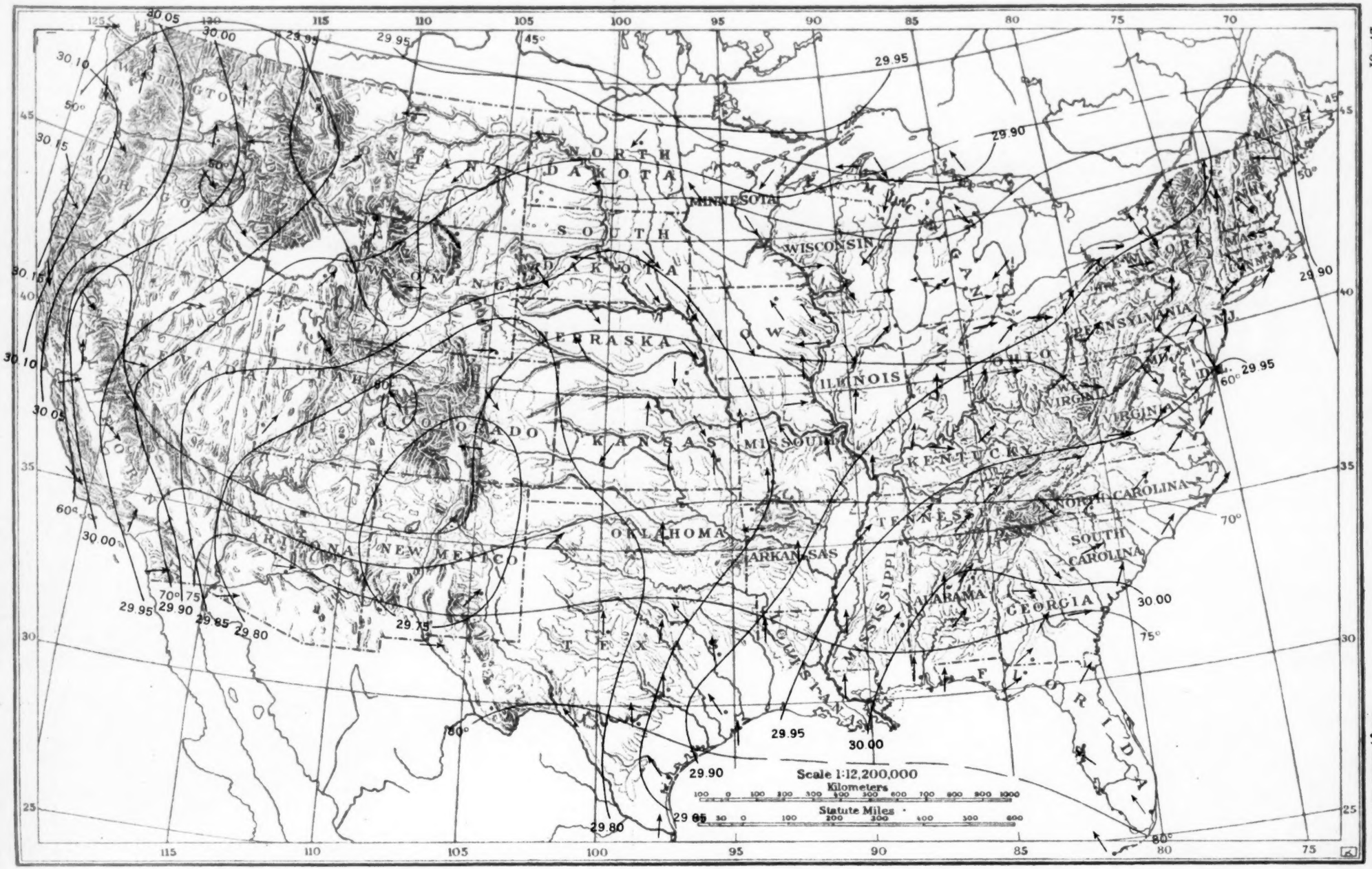


Chart VII. Weather Map of North Atlantic Ocean, May 3, 1927
(Plotted by F. A. Young)

Chart VIII.—Weather Map of North Atlantic Ocean, May 5, 1927

(Plotted by F. A. Young)

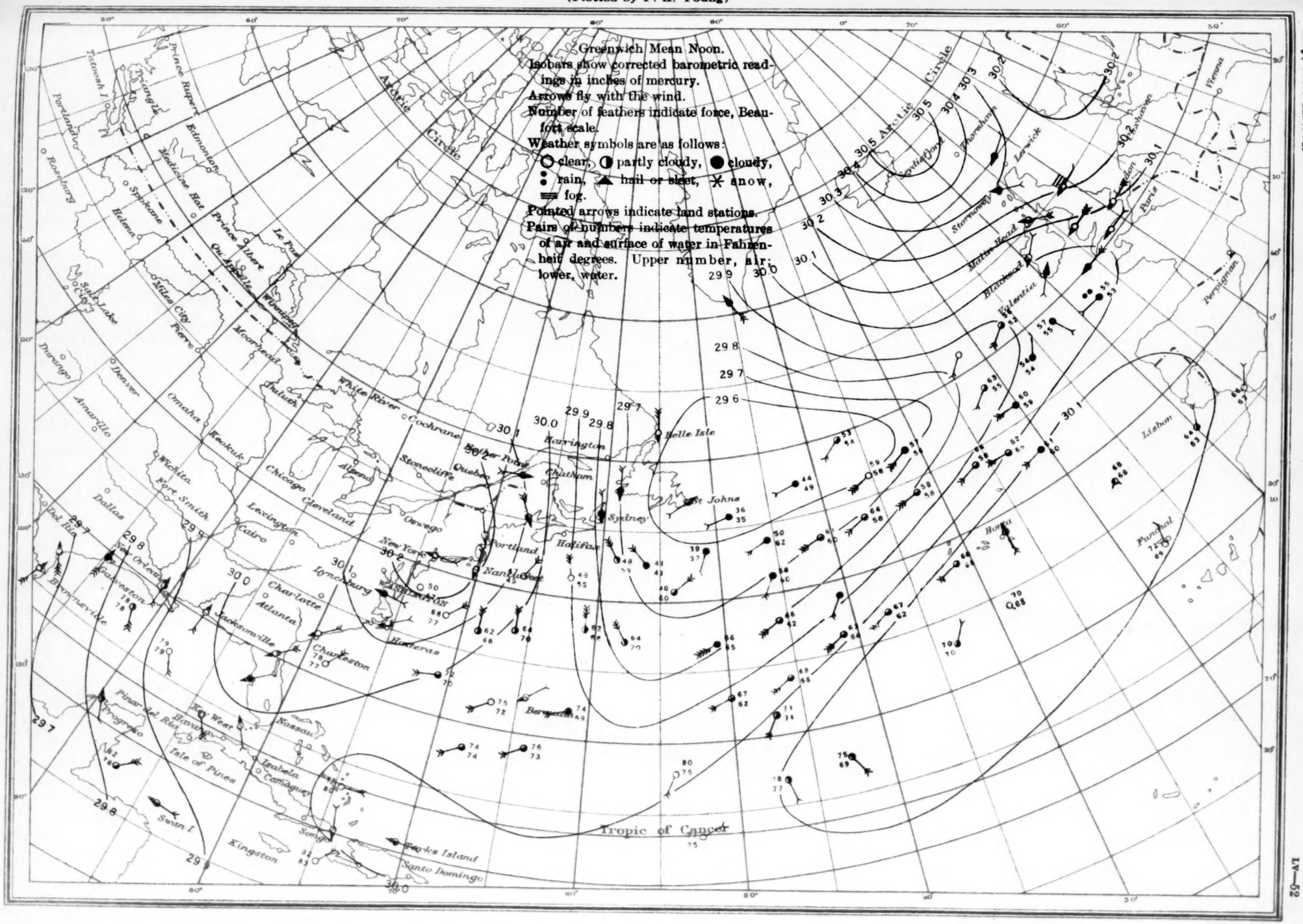


Chart IX. Weather Map of North Atlantic Ocean, May 9, 1927

(Plotted by F. A. Young)

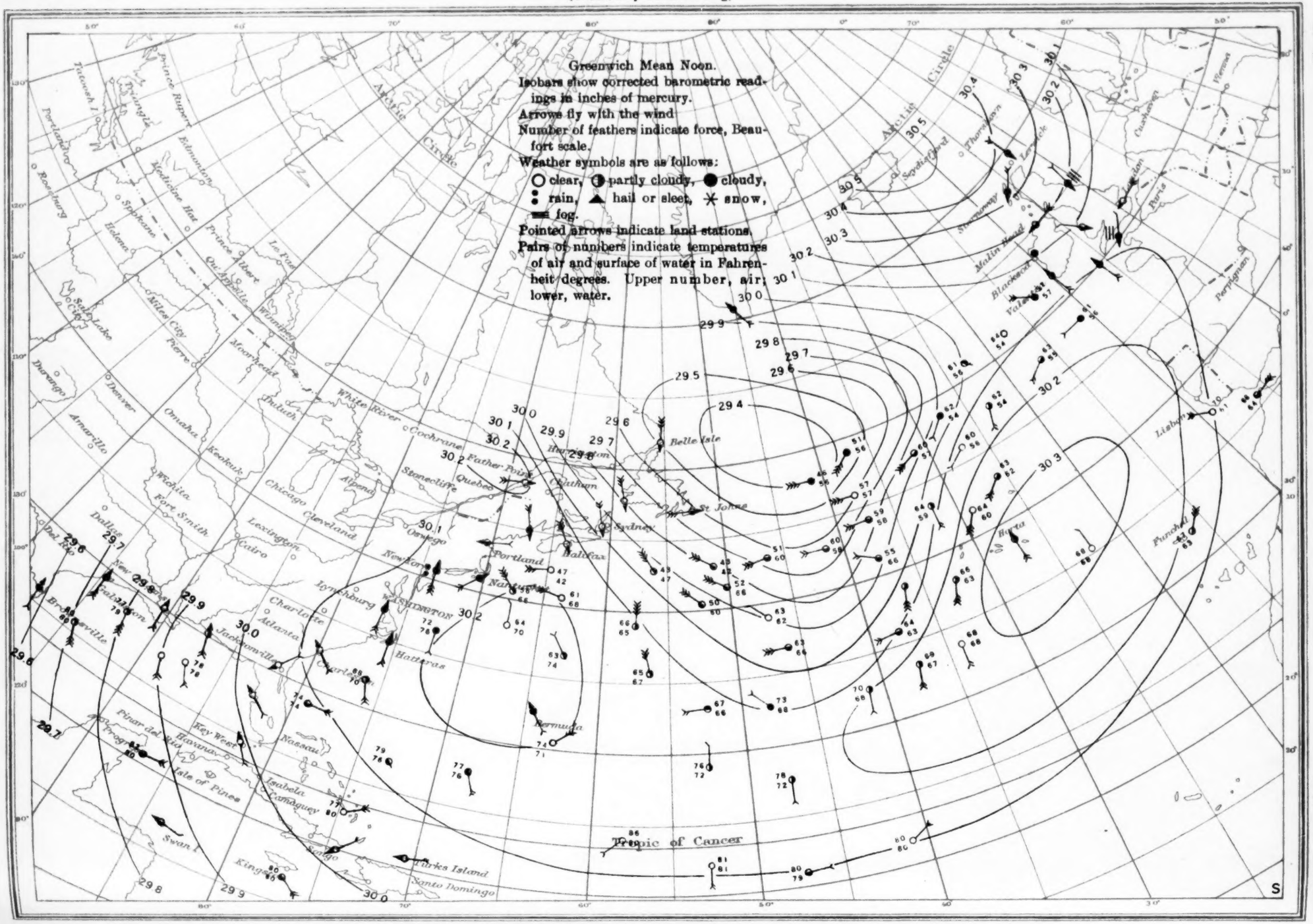


Chart X. Weather Map of North Atlantic Ocean, May 10, 1927

(Plotted by F. A. Young)

Chart X. Weather Map of North Atlantic Ocean, May 10, 1927
(Plotted by F. A. Young)

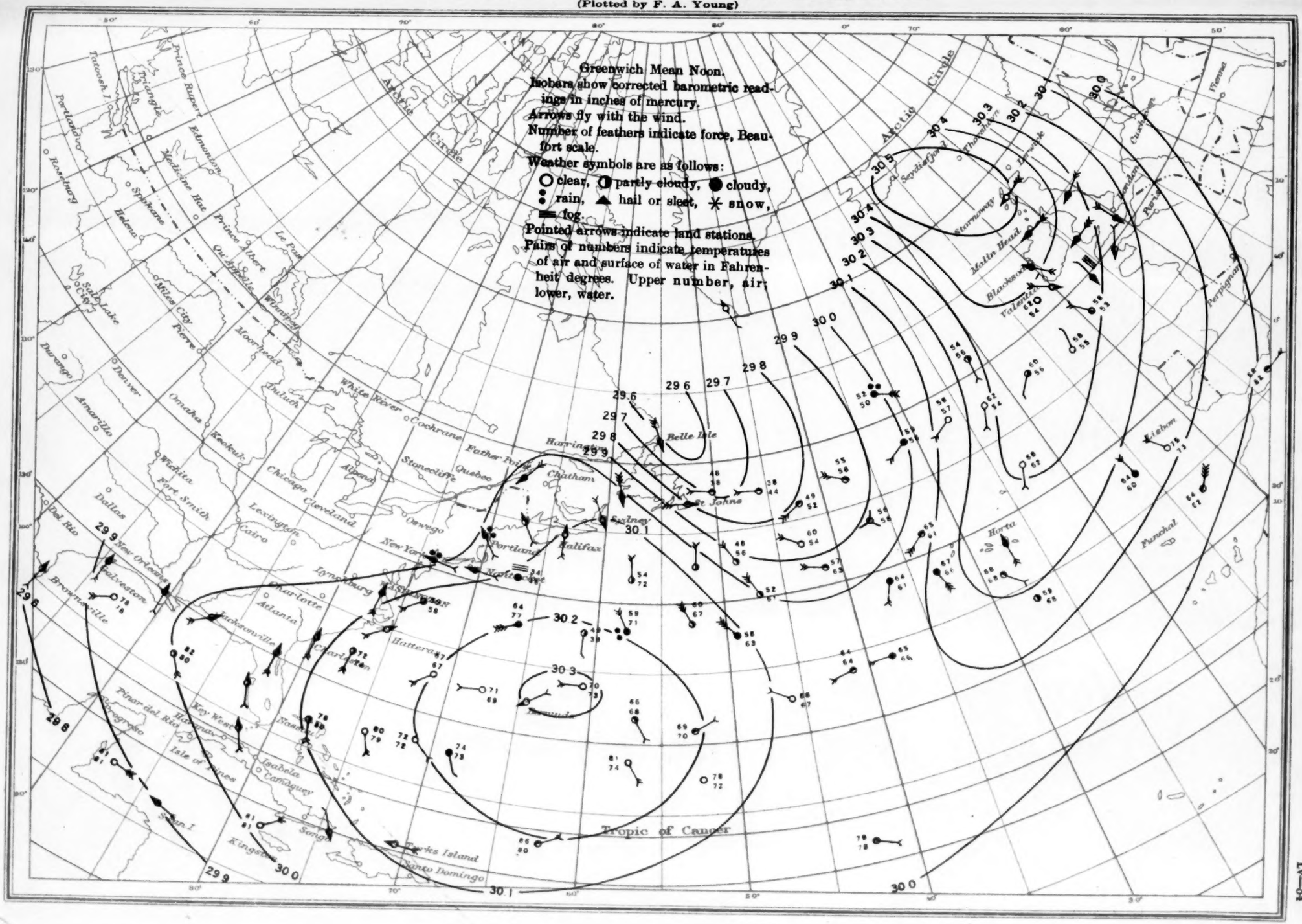


Chart XI. Weather Map of North Atlantic Ocean, May 19, 1927

(Plotted by F. A. Young)

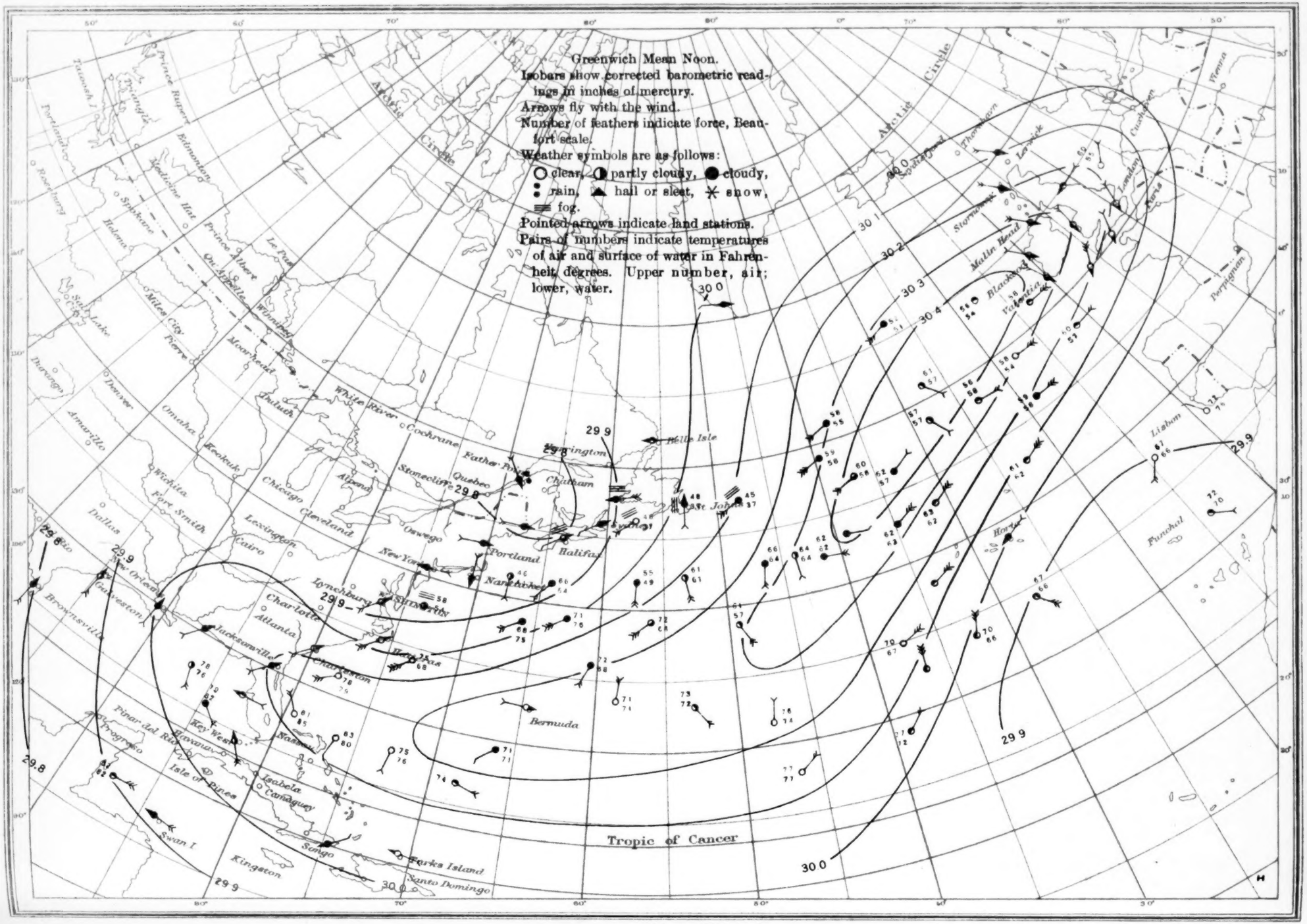


Chart XII. Weather Map of North Atlantic Ocean, May 20, 1927

(Plotted by F. A. Young)

Chart XII. Weather Map of North Atlantic Ocean, May 20, 1927
(Plotted by F. A. Young)

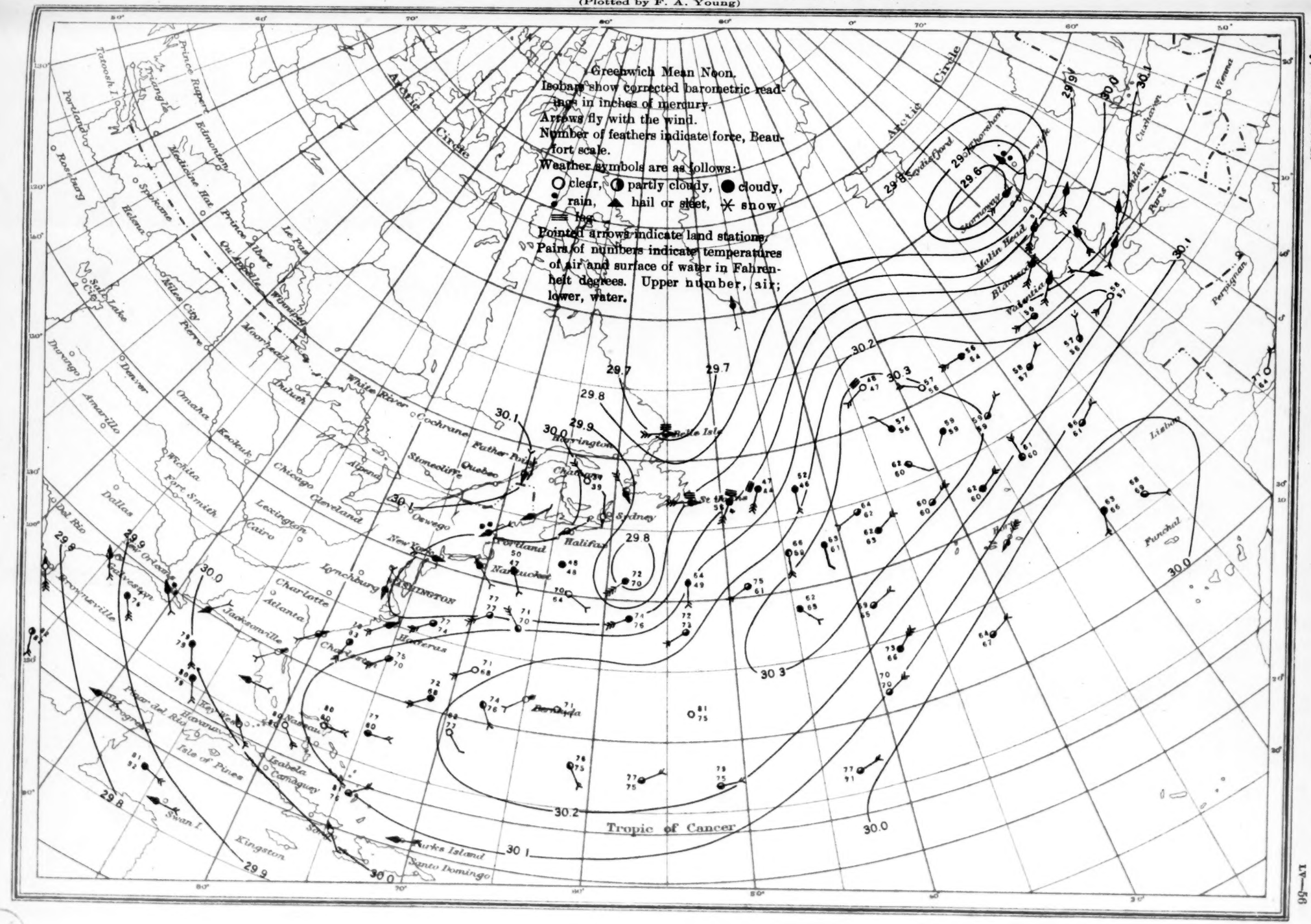
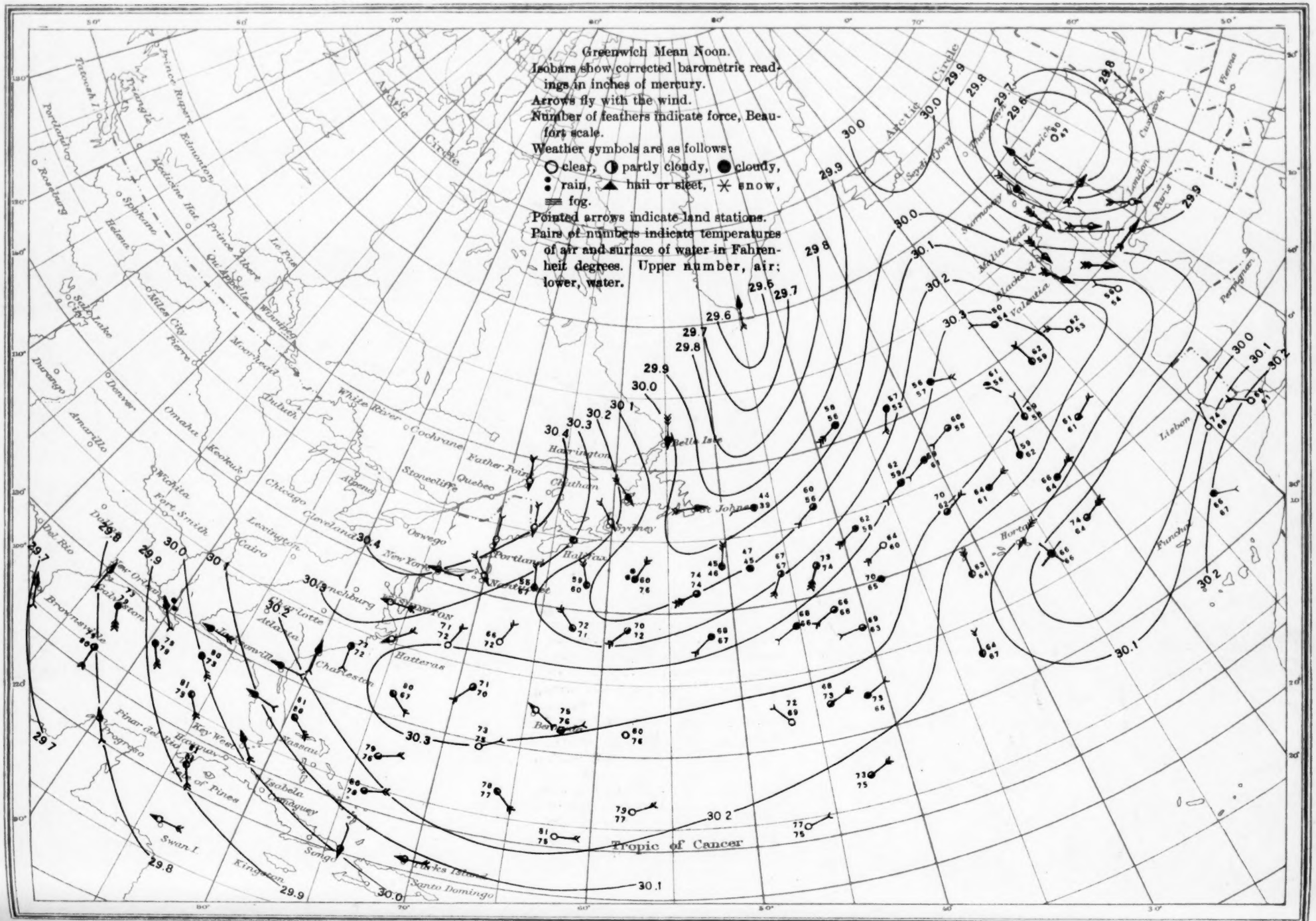


Chart XIII. Weather Map of North Atlantic Ocean, May 21, 1927

(Plotted by F. A. Young)